THE BULLETIN

OF THE

AMERICAN CERAMIC SOCIETY

Volume 16 SEPTEMBER, 1937 Number 9

See page 384 for story of Who Began Vitrified Porcelain Ceramic Ware?

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THE BULLETIN OF THE AMERICAN CERAMIC SOCIETY

Volume 16 September, 1937 Number 9

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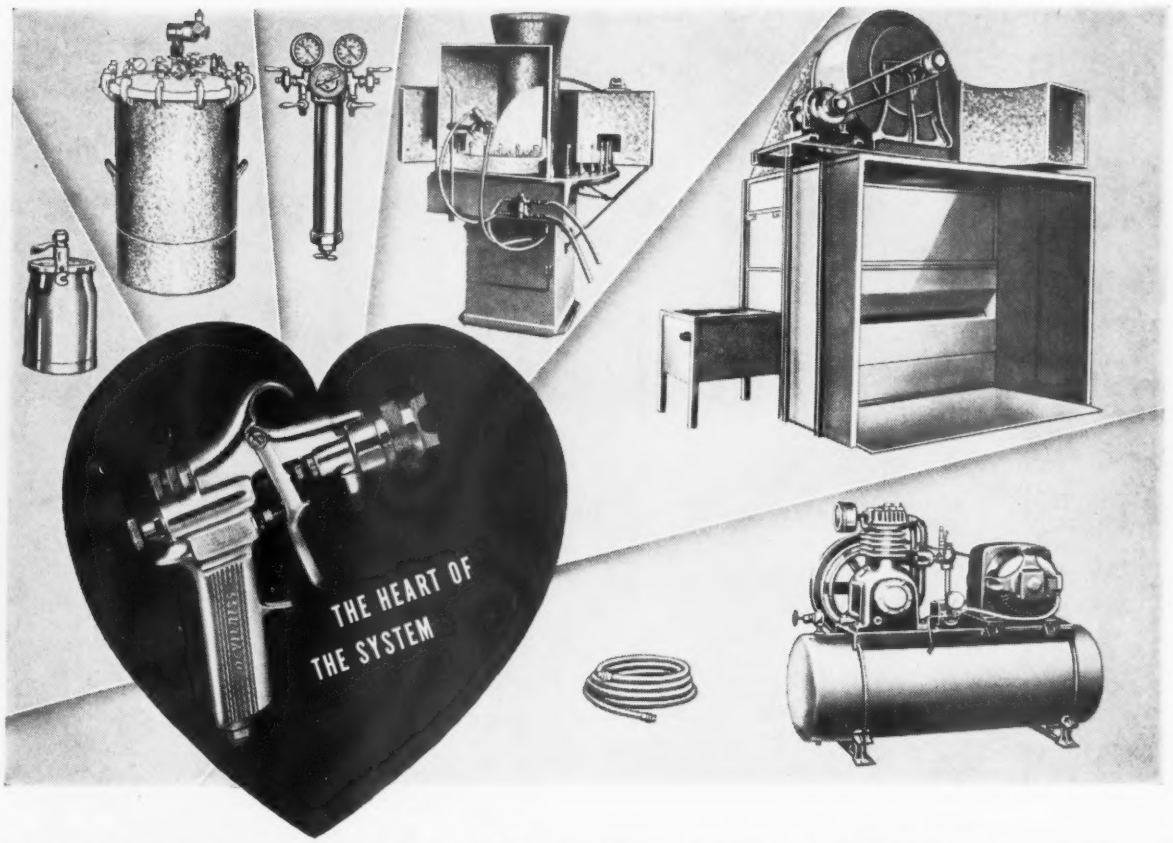

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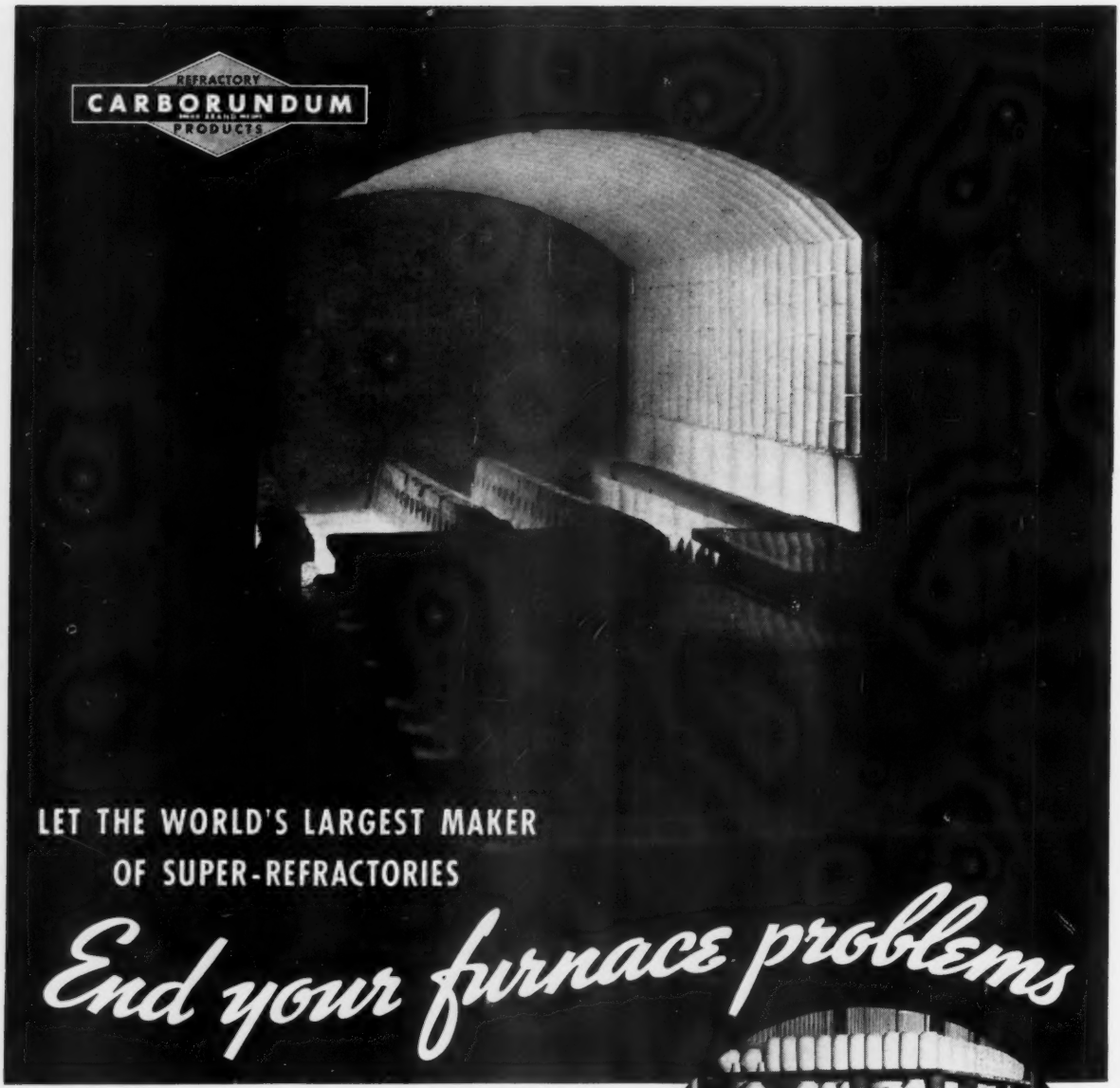

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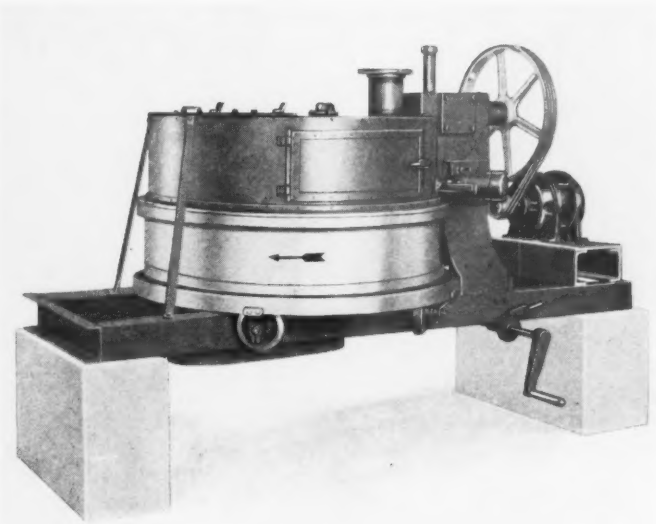

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Spinks Clay Co., H. C.
United Clay Mines Corp.

Clay (Potters)
Denver Fire Clay Co.
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
Sant, Richard C.
Spinks Clay Co., H. C.
United Clay Mines Corp.

Clay (Process Equipment)
Lancaster Iron Works, Inc.

Clay (Sagger)
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
The Hommel Co., O. Inc.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Pittsburgh Plate Glass Co.
Potters Supply Co.
Spinks Clay Co., H. C.
United Clay Mines Corp.

Clay (Wad)
Kentucky-Tennessee Clay Co.
Potters Supply Co.
Spinks Clay Co., H. C.
United Clay Mines Corp.

Clay (Wall Tile)
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Hammill & Gillespie, Inc.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Sant, Richard C.
Spinks Clay Co., H. C.
United Clay Mines Corp.

Cleaners
The Porcelain Enamel and Mfg. Co.

Cleaners, Chemical
Harshaw Chemical Co.

Clocks (Gauge Board)
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.

Cobalt Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
The Hommel Co., O., Inc.
Harshaw Chemical Co.
The Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Cobalt Sulphate
Harshaw Chemical Co.

Colors
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
The Hommel Co., O., Inc.
Harshaw Chemical Co.
Pittsburgh Plate Glass Co.
The Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Cones
The Edward Orton, Jr., Ceramic Foundation

Conveying Equipment
Frazier-Simplex, Inc.
Lancaster Iron Works, Inc.

Copper Oxide
Harshaw Chemical Co.

Corhart
Corhart Refractories Co.

Cornwall Stone (Imported)
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Paper Makers Importing Co.

Crucibles (Filter, Melting, Ignition)
Carborundum Co.
Denver Fire Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
Potters Supply Co.

Crushers (Clay)
Lancaster Iron Works, Inc.

Cryolite (see Kryolith)
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Crystolon (Refractory Products)
Norton Co.

Cullet, Washing Plants, Incinerators, Crushers
Frazier-Simplex, Inc.

Decorating Supplies
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
The Hommel Co., O., Inc.
Harshaw Chemical Co.
Pittsburgh Plate Glass Co.
The Vitro Mfg. Co.

Disintegrators
Lancaster Iron Works, Inc.

Dryer (Pipe Rack)
Lancaster Iron Works, Inc.

Drying Machinery
Frazier-Simplex, Inc.
Lancaster Iron Works, Inc.
Proctor & Schwartz, Inc.

Electrocast Refractories
Corhart Refractories Co.

Enameling Equipment (Complete)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Frazier-Simplex, Inc.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Enameling Furnaces
Carborundum Co.
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Electro Refractories & Alloys Corp.
The Hommel Co., O., Inc.
Lancaster Iron Works, Inc.
Norton Co.

Enameling Iron (Sheet)
American Rolling Mill Co.
Bethlehem Steel Co.

Enameling Muffles
Bethlehem Steel Co.
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Electro Refractories & Alloys Corp.
Frazier-Simplex, Inc.
Norton Co. (*Alundum*)
Pittsburgh Plate Glass Co.

Enameling (Practical Service)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
The Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Enamel Oxide
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.

Enamels (Porcelain)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
The Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Equipment (Porcelain Enameling)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The DeVilbiss Co.
The Hommel Co., O., Inc.

Exhaust Systems
The DeVilbiss Co.

Feldspar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Porcelain Enamel and Mfg. Co.
Sant, Richard C.
The Vitro Mfg. Co.

Fire Brick
Carborundum Co.
Corhart Refractories Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
Norton Co.

Fire Brick—Process Equipment
Lancaster Iron Works, Inc.

Fire Clay
Spinks Clay Co., H. C.

Flint
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Porcelain Enamel and Mfg. Co.

Flint Pebbles
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Floors (Non-Slip)
Norton Co.

Fluorspar
Harshaw Chemical Co.

French Flint
Consolidated Feldspar Corp.
Paper Makers Importing Co.

Frit
Allied Engineering Co.
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Frosting Mixtures
Harshaw Chemical Co.

Fuel Oil Systems and Control, Stokers
Bethlehem Steel Co.
Frazier-Simplex, Inc.

Furnaces
Allied Engineering Co.
Carborundum Co. (*Carboradiant*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Frazier-Simplex, Inc.
The Hommel Co., O., Inc.

Glass Bending Ovens, Glass Decorating Machines
Frazier-Simplex, Inc.

Glass Equipment
Hartford-Empire Co.
Lancaster Iron Works, Inc.

Glass Melting Pots (Open and Covered)
Pittsburgh Plate Glass Co.

Glass Melting Tanks and Furnaces
Frazier-Simplex, Inc.
Pittsburgh Plate Glass Co.

Glass Thickness Gauge
Bausch & Lomb Optical Co.

Glaze and Body Spar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Glazes and Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Glaze Spar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Paper Makers Importing Co.

Goggles
Cover, H. S.
Willson Products, Inc.

Gold
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. H. & Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Dept.

Gold Decorations
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Co.
Granulators
Lancaster Iron Works, Inc.
Grinding Wheels
Carborundum Co. (*Carborundum and Alorite*)
Chicago Vitreous Enamel Product Co.
Norton Co. (*Alundum-Crystolon*)
Hearths
Carborundum Co. (*Carbofrax* heat treating)
Corhart Refractories Co.
Electro Refractories & Alloys Corp.
Norton Co. (*Crystolon*)
Hearths (Fused Al_2O_3, SiC)
Electro Refractories & Alloys Corp.
Hearths (High Aluminous Clay, Electrically Sintered Aluminum Oxide, Silicon Carbide)
Carborundum Co.
Norton Co.
Hose (Air and Fluid)
The DeVilbiss Co.
Hydrofluoric Acid
Harshaw Chemical Co.
Iron Chromite
Harshaw Chemical Co.
Iron (Enameling)
American Rolling Mill Co.
Bethlehem Steel Co.
Iron Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.
Kaolin
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
Sant, Richard C.
United Clay Mines Corp.
The Vitro Mfg. Co.
Kellog AA Refractories
Electro Refractories & Alloys Corp.
Kilns, China (Decorating)
Allied Engineering Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
Frazier-Simplex, Inc.
The Hommel Co., O., Inc.
Kiln Furniture (Silicon Carbide, Semi-Silicon Carbide)
Electro Refractories & Alloys Corp.
Kyanite
Celo Mines, Inc.
Kryolith (See Cryolite)
Harshaw Chemical Co.
Pennsylvania Salt Mfg. Co.
Laboratory Ware
Norton Co.
Lehr Tile (High Aluminous Clay, Electrically Sintered Aluminum Oxide, Silicon Carbide)
Carborundum Co.
Electro Refractories & Alloys Corp.
Lehrs
Frazier-Simplex Inc.
Lehrs (Electric or Fuel Heated)
Frazier-Simplex, Inc.
Lehr Loaders
Frazier-Simplex, Inc.
Linings (Furnace Refractory, Block Refractory Plate, Brick and Tile)
Carborundum Co.
Chicago Vitreous Enamel Product Co.
Corhart Refractories Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
Norton Co.
Pittsburgh Plate Glass Co.
The Vitro Mfg. Co.
Lithium Carbonate
Foote Mineral Co.
Lithium Minerals
Foote Mineral Co.
Magnesia (Fused)
Electro Refractories & Alloys Corp.
Magnesia (Sintered, Calcined)
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Norton Co.
The Porcelain Enamel and Mfg. Co.
Magnesite
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.
Magnesite Calcined
Foote Mineral Co.
Magnesium Carbonate
Harshaw Chemical Co.
Manganese
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.
Manganese Dioxide
Foote Mineral Co.
Manganese (Oxide)
Ceramic Color & Chemical Mfg. Co.
Corhart Refractories Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
Masks (Breathing)
The DeVilbiss Co.
Willson Products, Inc.
Metals (Porcelain Enameling)
American Rolling Mill Co.
Bethlehem Steel Co.
Microscopes (Polarizing)
Bausch & Lomb Optical Co.
Minerals
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.
Mixers (Batch)
Lancaster Iron Works, Inc.
Mold Sanders
Lancaster Iron Works, Inc.
Muffles (Furnace)
Allied Engineering Co.
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
Frazier-Simplex, Inc.
Norton Co.
Pittsburgh Plate Glass Co.
Muffles (Laboratory)
Electro Refractories & Alloys Corp.
Mullite (Refractories)
Electro Refractories & Alloys Corp.
Muriatic Acid
Denver Fire Clay Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Needle Antimony
Harshaw Chemical Co.
Nickel Salts
Harshaw Chemical Co.
Nitrates (Cobalt, Sodium)
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.
Nitre
Harshaw Chemical Co.
Non-Gro Refractories
Electro Refractories & Alloys Corp.
Norbide (Norton Boron Carbide)
Norton Co.
Olivine
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Opacifiers
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.
Overglaze Colors
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Oxides
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.
Palladium Decorations
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Pins
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
Potters Supply Co.
Platinum Decorations
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Polariscopes
Bausch & Lomb Optical Co.
Frazier-Simplex, Inc.
Porcelain Enameling Service (Practical)
American Rolling Mill Co.
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
The Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.
Porcelain Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
The Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.
Potash (Carbonate)
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Solvay Sales Corp.
The Vitro Mfg. Co.
Producer Glass Plants
Frazier-Simplex, Inc.
Pug Mills
Lancaster Iron Works, Inc.
Pyrites (Natural Iron Sulphide)
Foote Mineral Co.
Pyrometer Tubes
Carborundum Co.
Electro Refractories & Alloys Corp.
Montgomery Porcelain Products Co.
Pyrometer Tubes (Refractory and Hard Porcelain)
Denver Fire Clay Co.
McDanel Refractory Porcelain Co.
Montgomery Porcelain Products Co.
Norton Co.
Pyrometers (Optical, Radiation, Surface, Immersion, Needle)
Pyrometer Instrument Co.
Pyrometric Cones
The Edward Orton, Jr., Ceramic Foundation
Raw Material Handling Equipment
Frazier-Simplex, Inc.
Lancaster Iron Works, Inc.
Refractometers
Bausch & Lomb Optical Co.
Refractories
Carborundum Co.
Corhart Refractories Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
Kentucky-Tennessee Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
Refractory Materials
Carborundum Co.
Chicago Vitreous Enamel Product Co.
Corhart Refractories Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
Kentucky-Tennessee Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
Sant, Richard C.
Titanium Alloy Mfg. Co.
Represses (Automatic)
Lancaster Iron Works, Inc.

Respirators
Chicago Vitreous Enamel Product Co.
Cover, H. S.
The DeVilbiss Co.
The Hommel Co., O., Inc.
Willson Products, Inc.

Rutile
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Foote Mineral Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Saggers
Carborundum Co.
Electro Refractories & Alloys Corp.
Norton Co.
Potters Supply Co.

Salt Cake
American Potash & Chemical Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.

Sandblast Helmets
Willson Products, Inc.

Sand Grinder and Sifters
Lancaster Iron Works, Inc.

Saponin
The Hommel Co., O., Inc.

Selenite of Sodium
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Selenium
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc. R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Sheets (Enameling Iron)
American Rolling Mill Co.
Bethlehem Steel Co.

Silica (Fused)
Electro Refractories & Alloys Corp.
The Hommel Co., O., Inc.

Silicate of Soda
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
The Hommel Co., O., Inc.
Harshaw Chemical Co.

Silicon Carbide
Carborundum Co.
Electro Refractories & Alloys Corp.
Norton Co.

Silicon Carbide Firesand
Carborundum Co.

Sillimanite Refractories
Electro Refractories & Alloys Corp.

Sillimanite (Synthetic)
Pittsburgh Plate Glass Co.

Slabs (Furnace)
Carborundum Co.
Electro Refractories & Alloys Corp.
Norton Co.
Pittsburgh Plate Glass Co.

Soda Ash
American Potash and Chemical Corp.
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
Solvay Sales Corp.
The Vitro Mfg. Co.

Sodium Antimonate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Vitro Mfg. Co.

Sodium Fluoride
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Sodium Metasilicate
Harshaw Chemical Co.

Sodium Nitrite
Harshaw Chemical Co.

Sodium Silica Fluoride
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.

Sodium Uranate
Harshaw Chemical Co.

Soot Blowers
Frazier-Simplex, Inc.

Special Machines
Frazier-Simplex, Inc.

Spar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Vitro Mfg. Co.

Spray Booths
The DeVilbiss Co.

Spraying Equipment
The DeVilbiss Co.

Spurs
Potters Supply Co.

Stacks
Lancaster Iron Works, Inc.

Steel Plate Construction
Bethlehem Steel Co.
Lancaster Iron Works, Inc.

Stilts
Potters Supply Co.

Sulfuric Acid
Denver Fire Clay Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.

Talc
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Paper Makers Importing Co.

Tanks
Frazier-Simplex, Inc.

Tank Blocks
Corhart Refractories Co.
Pittsburgh Plate Glass Co.

Tanks (Pickle)
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.

Tanks for Raw Material Steel or Concrete
Bethlehem Steel Co.
Lancaster Iron Works, Inc.

Tile (Floor)
Norton Co.

Tile (Muffle)
Carborundum Co.
Electro Refractories & Alloys Corp.
Norton Co.

Tile (Refractory)
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
Norton Co.
Pittsburgh Plate Glass Co.

Tile (Wall)
Denver Fire Clay Co.

Tin Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Vitro Mfg. Co.

Titanium
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Titanium Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Tri Sodium Phosphate
Harshaw Chemical Co.

Trucks
Lancaster Iron Works, Inc.

Tubes (Insulating)
Carborundum Co.
McDanel Refractory Porcelain Co.
Norton Co.

Tubes (Pyrometer)
Carborundum Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
McDanel Refractory Porcelain Co.
Montgomery Porcelain Products Co.
Norton Co.
Pittsburgh Plate Glass Co.

Uranium Oxide
Harshaw Chemical Co.

Uronium Oxide (Yellow-Orange-Black)
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
The Vitro Mfg. Co.

Water Softening Plants
Frazier-Simplex, Inc.

Wet Enamel
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
The Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Whiting
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
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PAPERS

THE REFRACTORY AND CERAMIC USES OF FUSED SILICA*

By William W. Winship

Abstract

Fused silica apparatus, on account of chemical inertness, low expansion, and certain other physical characteristics, occupies an important place for use outside the temperature possibilities of glass, stoneware, and porcelain. Vitreous silica in bulk, either by-product material or specially prepared, is a valuable ingredient in ceramic mixtures where severe temperature gradients are involved.

I. Introduction

Lechatelierite (natural fused silica), in the form of fulgurites, has been known for considerably more than a century. It is usually very fragile and frequently impure. Fused silica ware was produced from rock crystal in a laboratory less than fifty years ago, and the nontransparent product from glass sand was industrially made less than thirty years ago.

Credit for commercial production of nontransparent fused silica belongs to Bottomley[1] and his collaborators, Paget and Hutton.[2] They were successful in substituting electric resistance heating for the blowpipe and pure glass sand for rock crystal as the raw material. They also discovered that the fused material, taken directly from the electric furnace, retains sufficient plasticity and homogeneity to permit it to be blown or elongated by drawing during the brief time in which it cools to rigidity.

II. Conversion of Raw Materials

While unfused silica is hard and difficult to melt, it bears sudden changes of temperature very poorly, and it decrepitates when submitted to direct contact with the flame. After fusion, the product is indifferent to sudden temperature changes. It has a specific gravity considerably lower than that of quartz, which is 2.66; the specific gravity of transparent fused quartz is about 2.22 and of nontransparent fused silica about 2.07.

The statement that vitreous silica is unstable at all temperatures below 1710°C, the melting point of cristobalite, is scientifically correct. This product, however, is the only usable "glass" from 1100°C down to the upper useful limit for borosilicate glasses, which is several hundred degrees lower.

III. Technical Problems Involved

In the production of fused silica ware, silica itself is the raw material and the product; only the form is changed. Quartz changes into the glassy state at about 1700°C; at about 2000°C it is viscous and at 2600°C its vapor pressure is equal to one atmosphere. The vapor condenses to a white fleecy meal composed of tiny grains.

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 24, 1937 (Refractories Division).

[1] Frank Bottomley, "Fused Silica," *Jour. Soc. Chem. Ind.* [London], **36** [11] 577–80 (1917).

[2] J. F. Bottomley, R. S. Hutton, and Arthur Paget, "Manufacture of Silica Glass," U. S. Patent 812,399, Feb. 13, 1906.

While transparent fused quartz can be worked before the blowpipe, factory production of fused silica ware involves unique problems because the temperature range between the boiling and the melting points is narrow and without marked fluidity. Volatilization of the raw material occurs quickly on overheating, and heating under pressure is not practical.

Quoting from Bottomley,[1]

> "The chief difficulties in fusing quartz are due (1) to its very high melting point, (2) to the fact that the melting point and vaporizing temperatures lie very close together, and (3) to there being no material sufficiently refractory to act as the containing vessel in which it can be fused, nearly all materials reacting with silica at the fusion temperature."

IV. Manufacturing Technique

The following description of the process is essentially that contained in a patent[2] and its reissue[3] to Bottomley, Hutton, and Paget, and in a patent to Bottomley and Paget.[4]

The furnaces consist of iron boxes mounted on trunnions so as to be operative either in the vertical or the horizontal position. Electrode holders are at the ends. A graphite resistor rod of smaller diameter is supported between the electrodes. The box is filled with silica sand in which the graphite resistor is buried. By passing an electrical current through the resistor for a suitable period, a fused silica cylinder is formed about the resistance core. The size of the cylinder depends upon the quantity of electrical energy passed through the core and the length of time the heating is continued. Using as a resistor a graphite rod 24 inches long and 1 inch in diameter, about 1000 amperes at 15 volts for one-half hour may be required.

When fused silica, sufficient for the ware to be made, surrounds the core, the current is cut off, the electrodes are drawn back, and the graphite core is removed. To facilitate the withdrawal of the resistor, the heating of the furnace is continued until an initial separation between the core and the inner surface of the plastic cylinder has taken place, owing to the formation of a small quantity of gas on the surface of the core.

As soon as the electrodes and core are entirely free from the furnace, the plastic cylinder of silica is ready for further manipulation. After removing the softened mass from the furnace, the entire forming process has to be completed within a few seconds, because the melt cools so rapidly that shaping it into ware would otherwise be impossible. The loss of temperature in the cooling mass has been estimated at 50° to 60°C per second.

The plastic silica cylinder formed about the resistor rod can be immediately drawn into tubing by processes similar to those used in the manufacture of glass tubing. Fused silica is extremely ductile while in the plastic condition and can be drawn out into lengths of 90 to 100 feet.

If hollow bodies of greater diameter than the original fusion are required, the hollow plastic cylinder is closed at one end by mechanical pressure and extended in a suitable mold by gaseous pressure introduced in any convenient way, for example, by compressed air through a refractory nozzle.

To produce tubing, a refractory nozzle is inserted in one end of the plastic cylinder, and the plastic material is pressed around it by a pair of tongs. The other end of the cylinder is simultaneously closed by the pressure of a second pair of tongs. The cylinder is then removed from the furnace and drawn out, compressed air being admitted to produce cylindrical tubing of any desired diameter. When the cylinder is removed from the furnace, the outside is hard, and, before it can be drawn, considerable force has to be employed to overcome the external chilling. When this has been done, the mass becomes much more plastic and can easily be drawn out. For example, in drawing tubing from a plastic cylinder unglazed on the outside, a pull of fifty-five pounds was required to overcome the initial resistance, which fell to twenty-five pounds as soon as the material began to draw.

Because the furnace is packed with the raw material considerably beyond that at which the actual fusion ceases, the cylinder has a rough sandy exterior, even after the unfused sand adhering to the outer skin has actually been removed by sandblasting. The structure of the ware, however, is thoroughly vitreous and homogeneous.

The product resulting from the method worked out by Bottomley and Paget has a fibrous structure due to its extension in the process of drawing,

[3] J. F. Bottomley, R. S. Hutton, and R. S. Paget (The Thermal Syndicate, Ltd.), "Manufacture of Silica Glass," U. S. Patent Reissue 13,504, Jan. 7, 1913.

[4] J. F. Bottomley and Arthur Paget, "Process for Fusing Silica and for Shaping the Mass While Plastic," U. S. Patent 822,424, June 5, 1906.

rolling, pressing, or the like. It is distinguished from the sand fusions made by earlier experimenters by the fact that the material is extended while in the original plastic condition.

The weight of fused material which can be worked at the present time is in excess of two hundred pounds, which is a great advance compared with the small pieces produced in the blowpipe from bits of crystal quartz.

Fusion in high-frequency furnaces and in the electric arc is resorted to in special instances.

To produce a cylindrical article glazed externally, the rough cylinder may be further treated in a separate furnace, consisting of a tube of suitable resistance material fixed between two electrodes. The interior of the furnace may contain nitrogen or other inert gas. Immediately after removal from the original melting furnace, the cylinder is subjected, in this second furnace, to radiant heat sufficient to melt the exterior layer of agglomerated material. As soon as this glazing operation has been effected, the plastic cylinder is ready for subsequent manipulation. By an alternative method, a material glazed throughout may be produced in the original melting furnace.

Small laboratory ware requiring a smooth, highly finished outside surface is produced by blowing in gang molds, by grinding, and finally by fusing the surface either electrically or in the oxyhydrogen blowpipe. The exterior coating of loose, fritted grains of sand, which is characteristic of the melt produced in the original furnace, forms a protective layer preventing injury of the plastic silica mass while in contact with tools and molds. Small laboratory articles may be produced from thin plates heated by the blowpipe or electric arc and pressed against graphite molds either by the action of the heating means or by compressed air or suction.

On account of the extreme viscosity of plastic silica, it is difficult to remove from the wall structure the fine bubbles formed from the gases accompanying the original grains of sand, and this prevents the ware produced from sand from being entirely transparent; in most cases, however, this is not an important point in the technical applications of the product. Subsequent heating in the oxyhydrogen flame generally increases the translucency of the product; the glazing operation also improves it in this respect and also increases the homogeneity and imperviousness of the ware. The lustrous interior appearance of the articles with rough exterior is attributable to reflection from the included bubbles.

The large-scale production of nontransparent fused silica has led to developments in the manufacture of transparent fused quartz in larger sizes and at less expense by modifications of the same method. Even the latest methods of making the transparent product, however, still call for the use of rock crystal (usually obtained from Brazil or Madagascar) as the raw material, which is fused in electric vacuum furnaces after crushing and washing in acid and water.

According to Clark,[5] Kent and Lacell's process is used commercially for producing fused quartz articles of small size. He described the process as follows:

> "A transparent fused quartz tube or core is rotated in front of a source of heat such as an oxyhydrogen blowpipe or electric arc and while still soft, powdered quartz is allowed to fall onto it. The grains adhere to the hot surface of the core and are fused into it, thus gradually building up an ingot which can subsequently be worked up by blowing into various articles or by drawing into tubing."

V. Two General Classes of Product

It is surprising that there is such a difference in the structure of fused silica from the two raw materials, rock crystal and silica sand. Viewed under the microscope, the sand grains are about as transparent as the rock crystal powder prepared by quenching, and equally clear fusions might well be expected to result.

The matter has been investigated by Rayleigh,[6] who explains that owing to the geological history of sand, which in many cases is the residue from granite formed under great pressures, the grains contain water and carbon dioxide. The water-vapor and gas develop internal bubbles during the fusion, many of which are unable to escape and remain trapped in the finished product.

The ware produced by the method of Bottomley and Paget is usually known as "fused silica ware," while the transparent ware made by the fusion of rock crystal is known as "fused quartz ware," or less correctly but more commonly, as "quartz glass." In chemical purity and behavior, high-temperature resistance, and indiffer-

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[5] R. W. Clark, "Fused Silica, Its Properties and Applications," *Trans. Roy. Scottish Soc. Arts*, **8**, 112–37 (1934).

[6] Rayleigh, "Notes on Silica Glass," *Proc. Opt. Conv.* (I), 41–46 (1926).

ence to sudden changes of temperature, the two products are identical despite their considerable difference in appearance. The close agreement in the physical properties of the transparent and the nontransparent varieties is illustrated by the practicability of composite articles, such as opaque pipes or tubes with transparent fused-in sections for high-temperature work and non-transparent mirror blanks with transparent layers deposited by the oxyhydrogen blowpipe. The fused quartz ware is about 10% heavier than the nontransparent type and several times as strong mechanically. It closely resembles glass in appearance but has the characteristic property of transparency to light of short wave-lengths.

VI. General Properties of Vitreous Silica

Paget[7] describes certain mechanical properties of transparent fused quartz as follows:

> "Its modulus of elasticity is rather higher than Jena glass; its crushing strength between that of granite and blue brick. Its tensile strength in the form of fibers is equal to that of high carbon spring steel and its shear rigidity modulus slightly higher than that of crown glass."

Tests made in the engineering laboratory of Columbia University on opaque fused-silica cylinders, ranging from 4 to $9\frac{1}{2}$ inches internal diameter with walls of about $\frac{1}{2}$ inch in thickness, indicated that at ordinary temperatures a dead load of about 7 tons per square inch could be safely applied to these cylinders. No attempts were made to determine the safe load at elevated temperatures as the results obtained indicated that the safety factor was extremely high.[8]

The thermal conductivity of fused silica is of the same order as that of ordinary glass but apparently increases more rapidly with rise in temperature. Glazed fused silica is apparently a considerably better conductor of heat than porcelain.

VII. Negligible Thermal Expansion

The expansion of fused silica made from sand and the product made from rock crystal is practically the same. Randall's[9] figure, 54×10^{-8} as the mean coefficient of linear expansion from 0° to 1000°C, may be considered as thoroughly reliable.

The National Bureau of Standards[10] gives a résumé of the average coefficients of expansion of fused silica over the ranges between 20° to 60°C and 20° to 1000°C determined on seventeen samples.

The expansion of fused silica is expressed by a curve which is practically a straight line, whereas the coefficients of other materials, taken at about 20°C, generally increase with rising temperature. On account of its low expansion, vitreous silica has become a standard on determining expansion coefficients, and it is employed in the form of tubes and rods as heating chambers and plungers in the construction of dilatometers. In the interferometer method, fused quartz endplates and windows are employed. Fused quartz standards of length have also been constructed by our own and foreign governments.

VIII. Useful Temperature Limits

The user of fused silica or quartz ware should keep in mind 1100°C as the highest temperature for long exposure of the ware, for at approximately this temperature devitrification begins to set in. The softening temperature at about 1400°C and the melting point at about 1750°C are less important.

Austin and Mellor[11] found that fused silica tubes fired seven times for 48 hours at 1350°C crumbled away.

Simonis[12] of the Berlin Royal Porcelain Manufactory found fused quartz suitable for use under oxidizing conditions up to 1300°C, and transparent fused quartz tubes used for pyrometer protection have been known to last for twenty-five to thirty firings of 24 hours at 1400°C.

Bigot[13] reports that fused quartz falls to powder when heated for 4 hours at 1450°C.

Blackie's[14] report of the investigations of the

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[7] R. A. S. Paget, "History, Development, and Commercial Uses of Fused Silica," *Jour. Roy. Soc. Arts*, **72** [3724] 323–39 (1926).

[8] S. L. Tyler, "Fused Silica, Its Properties and a Few of Its Uses," *Trans Amer. Inst. Chem. Eng.*, **11**, 189–202 (1918).

[9] H. M. Randall, "Expansion of Fused Quartz at High Temperatures," *Phys. Rev.*, **30** [2] 216–35 (1910).

[10] Wilmer Souder and Peter Hidnert, "Measurements on the Thermal Expansion of Fused Silica," *Bur. Stand. Sci. Paper*, No. 524, 23 pp. (April 13, 1926).

[11] T. J. Austin and J. W. Mellor, "Action of Heat on Quartz and Magnesia Pyrometer Tubes," *Jour. Soc. Chem. Ind.* [London], **26** [8] 380 (1907).

[12] M. Simonis, "Zur Verwendung von Geschmolzener Magnesia, Quarzglas, und Carborund als Schwerschmelzbare Materialien," *Sprechsaal*, **40** [1] 3 (1907).

[13] A. Bigot, "Notes on New Experiments on Silica Materials," *Trans. Ceram. Soc.* [Eng.], **18**, 362 (1919).

[14] A. Blackie, "Behaviour of Fused Silica at High Temperatures," *Trans. Faraday Soc.*, **7** [1–2] 158–65 (1911).

National Physical Laboratory contains the data which are usually quoted in connection with fused silica devitrification. Blackie says,

> "In general, loss of strength hardly commenced at 1120°C, at 1188°C it exists but is not very serious even after eight hours, but four hours' heating at 1353°C makes a reduction of 40 to 60%, showing that the rate of loss of strength increases very rapidly as the temperature rises."

Thomas' contention,[15] *viz.*, that the addition of titania or zirconia increased the mechanical strength and resistance to devitrification of fused quartz, was controverted by Rieke and Endell[16] and by Michie,[17] who found on the contrary that the addition of such substances materially decreased the high-temperature resistance of the ware. Others who have studied the devitrification of fused silica are Crookes,[18] Seger and Cramer,[19] and Rebuffat,[20] and the following conclusions seem to be justified from their researches:

All varieties of fused silica and fused quartz become crystalline upon slow heating at high temperatures, the rapidity of devitrification depending not only upon the temperature but on the surrounding atmosphere. It has been found that near the critical temperature, fused silica devitrifies more rapidly in a reducing atmosphere than if heated in an oxidizing one.

Devitrification is usually due to the reversion of the amorphous fused silica to the high-temperature crystalline form, cristobalite. Since the specific gravity of fused quartz is less than that of cristobalite (2.33), the degree of devitrification can be estimated from the increase in specific gravity. Unlike most crystalline changes in silica, which can be followed only microscopically, the devitrification of fused silica, especially when far advanced or occurring in the clear transparent product, is readily detectable by the eye.

The conversion of vitreous silica to high-temperature crystalline forms agrees in general with the phenomena observed in the case of silica brick. If the temperature is high enough for crystallization and fluxes are absent, cristobalite will first be formed and then revert to tridymite in the latter's stability range. If the crystallization takes place in the stability range of cristobalite, above 1470°C, the latter will be formed and persist. If the temperature lies within the stability range of tridymite, between 870° and 1470°C and fluxes are present, both tridymite and cristobalite will be formed.

The extent of devitrification is not dependent on the temperature and surrounding atmosphere alone, but on the amount of surface exposed and the period of heating. The transparent fused quartz appears to be more resistant to devitrification than the nontransparent fused silica ware, the more numerous bubbles in the wall structure of the latter evidently serving as nuclei for devitrification.

As a practical consideration, while fused silica ware is not recommended for continuous work at temperatures in excess of 1100°C, it will give satisfactory results on intermittent work at much higher temperatures, such as pyrometric measurements. Rieke and Endell[16] believe that the life of fused quartz ware can be considerably lengthened for high-temperature work, if, following its first heating, the temperature is not permitted to fall below 300°C.

NOTE: The Geophysical Laboratory at Washington has published a number of papers relative to the mineralogy of silica including the relations between fused silica and the various crystalline varieties. In fact Day and Shepherd[21] produced transparent fused quartz experimentally and have given an interesting record of the difficulties encountered.

IX. Permeability

The permeability of fused quartz has been the subject of research by various investigators who have found, in general, that the volume of gas diffusing through the ware increases with the pressure and very rapidly with the temperature.

It was early discovered[22] that the diffusion of helium through fused quartz was sufficient at high temperatures to make this material unsuitable for use in the construction of high-temperature gas thermometers. Work done at the

[15] Felix Thomas, "Siloxyd, ein Höherwertiger Ersatz des Quarzglases," *Chem.-Ztg.*, **36** [4] 25–27 (1912).

[16] Reinhold Rieke and Kurd Endell, "Entglasung von Quarzgläsern," *Silikat-Z.*, **1** [1] 6–12 (1913).

[17] A. C. Michie, "Zur Frage der Entglasung von Quarzglas," *Chem.-Ztg.*, **37** [58] 589–90 (1913).

[18] William Crookes, "Devitrification of Silica Glass," *Chem. News*, **105** [2376] 205 (1912).

[19] H. Seger and E. Cramer, "Quarzgläser," *Tonind.-Ztg.*, **37** [42] 560 (1913).

[20] Orazio Rebuffat, "Sulla transformazione del quarzo in tridimite," *Giorn. chim. ind. applicata*, **2** [8] 437–38 (1920).

[21] A. L. Day and E. S. Shepherd, "Quartz Glass," *Science* [N.S.], **23** [591] 670–72 (1906).

[22] Adrien Jaquerod and F. L. Perrot, "Sur l'emploi de l'helium comme substance thermomètrique et sur sa diffusion à travers la silice," *Compt. rend.*, **139**, 789–90 (1904).

Reichsanstalt[23] indicated that the diffusion of helium through fused quartz at ordinary temperatures was about ten times that of hydrogen, an observation which has been confirmed elsewhere.

Bodenstein and Kranendieck[24] found no porosity to ammonia or nitrogen in fused quartz vessels at a temperature of about 800°C, and several other investigators have found no appreciable diffusion of nitrogen until very high temperatures are reached. Mayer[25] found no leakage of oxygen at pressures of less than one atmosphere, and, in his experiments using hydrogen, oxygen, and nitrogen under approximately the same conditions, hydrogen was found to diffuse the most rapidly and nitrogen the least readily through fused quartz.

Williams and Ferguson[26] found no leakage of air or nitrogen through fused quartz with pressures up to one atmosphere and temperatures up to 881°C. They report an appreciable permeability to hydrogen at 300°C, and at 500°C a permeability to helium about 22 times that of hydrogen. Helium permeability is easily measured at 180°C.

Considering the application of fused silica to the construction of high-power electronic discharge tubes, Johnson and Burt[27] studied the flow of hydrogen through this material under high vacuum and high temperature, and included some measurements with nitrogen and argon. Perceptible diffusion began with hydrogen at about 300°C and with nitrogen at 600°C. Preliminary tests on several varieties of opaque fused silica showed this to be unsuitable for high-vacuum apparatus even at room temperature, so the final study was limited to transparent fused quartz. With regard to the latter, they remark "we can probably say that a well-evacuated bulb of one liter capacity can be kept in the air at 400°C for 100 hours before the pressure reaches 10^{-4} millimeters, and the transfused gas will be largely nitrogen."

T'sai and Hogness[28] investigated the diffusion of gases through fused quartz and give data for helium and neon.

> "As one would expect, permeability is greater for the atoms or molecules of smaller cross section. The heavier rare gases would undoubtedly diffuse so slowly as to prohibit detection, if any diffusion at all took place."

In investigating the diffusion of helium through fused quartz, Burton, Braaten, and Wilhelm[29] found that this was appreciable at room temperature and atmospheric pressure. A fused quartz plate with ground surface was only slightly more porous than a bulb with smooth transparent surfaces. Crystal quartz plates, whether cut perpendicular or parallel to the optical axis, showed only about one-half the permeability of fused quartz.

Barrer[30] investigated the velocity of the diffusion of helium, hydrogen, oxygen, nitrogen, argon, and air through transparent fused quartz from room temperatures up to 1000°C at atmospheric pressure. He reports that prolonged heat treatment greatly decreases porosity toward oxygen, nitrogen, argon, and air, but that a brief treatment with hydrofluoric acid restores the original porosity.

The characteristic properties of vitreous silica can be employed to advantage in constructing vacuum vessels for high-temperature work. Porcelain does not usually give satisfactory results under vacuum (its impermeability depends upon the glaze which is likely to contain small defects), while glass is strictly limited as to the temperature conditions under which it may be employed. Apparatus of fused quartz makes possible the exhaustion, baking, and operation of electrical devices at much higher temperatures than with glass and frequently permits a reduction in size. If desired, such devices can be cooled by an air blast during operation without injury to the fused-quartz envelop.

Kaye[31] points out the necessity of heating

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[23] Anon., "Tätigkeit der Physikalisch-Technischsen Reichsanstalt im Jahre 1911," *Z. Elektrochem.*, **18** [18] 823–32 (1912).

[24] M. Bodenstein and F. Kranendieck, "Zertsetzungsgeschwindigkeit des Ammoniaks in Quarzglas," Nernst-Festschrift, p. 99. Wilhelm Knapp, Halle a. S., 1912.

[25] E. C. Mayer, "Leakage of Gases through Quartz Tubes," *Phys. Rev.*, [2] **6** [4] 283–91 (1915).

[26] G. A. Williams and J. B. Ferguson, "Diffusion of Hydrogen and Helium through Silica Glass and Other Glasses," *Jour. Amer. Chem. Soc.*, **44** [10] 2160–67 (1922).

[27] J. B. Johnson and R. C. Burt, "Passage of Hydrogen through Quartz Glass," *Jour. Opt. Soc. Amer.*, **6** [7] 734–38 (1922).

[28] L. S. T'sai and T. R. Hogness, "Diffusion of Gases through Fused Quartz," *Jour. Phys. Chem.*, **36,** 2595–2600 (1932); *Ceram. Abs.*, **12** [2] 54 (1933).

[29] E. F. Burton, E. O. Braaten, and J. O. Wilhelm, "Diffusion of Helium through Quartz: Relation to Temperature," *Can. Jour. Research*, **8** [5] 463–67 (1933).

[30] R. M. Barrer, "Mechanism of Activated Diffusion through Silica Glass," *Jour. Chem. Soc.* [London], 1934, [I] 378–86.

[31] G. W. C. Kaye, High Vacua, pp. 37–38. Longmans, Green, & Co., Ltd., London, 1927.

glass apparatus to the highest practicable temperature while pumping, if a high vacuum is required. Approximate temperatures which he mentions as suiting various materials are 400°C for lead glass, 500°C for soda glass, 700°C for borosilicate glass, and 1000°C for fused quartz.

X. Electrical Properties

The electrical properties of fused silica ware have made it important in certain specialized applications, and it is probable that its use in electrical fields will be greatly extended when it is possible to produce certain forms of apparatus which are not now practicable on a commercial scale. Boys[32] has shown that fused silica is an excellent electrical insulator even in an atmosphere saturated with moisture. Wood[33] declares that fused quartz is one of the best electrical insulators available, and Peaslee[34] states that insulators should be made from an amorphous substance containing only one constituent (or constituents of the same electrical and thermal characteristics), indicating that fused quartz is practically an ideal insulating material.

The Bureau of Standards[35] in 1914 published a table of volume resistivities including fused quartz, which data, determined at room temperature, do not show the superiority of this ware as a high-temperature electrical insulator. It, however, heads the list with the same value as two other materials having very low melting points; hard rubber, mica, porcelain, and German glass have much smaller electrical resistance even at normal temperatures. This investigation also showed the similarity in electrical behavior of several specimens of fused quartz from various sources.

The Bureau of Standards made some further investigations of insulating materials for the National Advisory Committee for Aeronautics in 1920,[36] the substances studied being those sufficiently heat-resisting for use in spark plugs and comprising available porcelains, glass, steatite, mica, and fused silica, the last proving to be the best material tested. The fused silica with which they worked was the clear transparent variety.

Davidson[37] found fused silica tubes with the outside surface fused smooth, the ideal form of insulating bushing for detarring gas by electrical precipitation under conditions where the insulator was subject to very considerable leakage or possible breakdown due to the deposition of a layer of tar on its surface. Davidson says,

> "The flaming discharge over a carbonized line will, in a very short time, cut into composite insulators, such as bakelite, micanite, etc. Insulators of earthenware, porcelain, etc., either cracked throughout their length or the glazing broke under the line of discharge. Carbon would then be deposited in the porous material beneath and would remain as a permanent conductor."

All of the bushings he used, except those made from fused silica, were destroyed at the first breakdown of the insulation. The flaming discharge over a coating of carbonized tar on the surface of the silica bushing did not injure the latter and could be removed by an intense flame.

Moon and Norcross,[38] investigating the dielectric strength of various glasses, fused quartz, celluloid, and mica, found that fused quartz has a breakdown strength of 5,000,000 volts per centimeter in the disruptive region, a higher value than any other material tested except mica. This value is independent of thickness and temperature when the latter is below about 0°C. For higher temperatures, the breakdown gradient of the material is reduced but always remains higher than the corresponding values for the glasses or for celluloid.

Patrick and Peel[39] point out the special value of fused silica details in insulating high-frequency induction furnaces. Here the refractory requirements are extremely severe, necessitating a very low power factor or dielectric hysteresis, high dielectric strength at elevated temperatures, and resistance to thermal shock.

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[32] C. V. Boys, "Quartz as an Insulator," *Phil. Mag.*, [5] **28** [142] 14–17 (1889).

[33] R. W. Wood, "Preliminary Note on the Electron Atmospheres of Metals," *ibid.*, [6] **24** [140] 316–22 (1912).

[34] W. D. Peaslee, "Insulator Situation," *Proc. Amer. Inst. Elec. Eng.*, **36** [5] 401–407 (1917).

[35] H. L. Curtis, "Insulating Properties of Solid Dielectrics," *Bur. Stand. Sci. Paper*, No. 234, 64 pp. (June 18, 1914).

[36] (*a*) F. B. Silsbee and R. K. Honaman, "Methods of Measuring Resistance of Insulators at High Temperatures," *Nat. Advisory Comm. Aeronautics Report*, No. 53 [Part I] pp. 79–89 (1920).

(*b*) R. K. Honaman and E. L. Fonseca, "Electrical Resistance of Various Insulating Materials at High Temperatures," *ibid.*, No. 53 [Part II] pp. 91–99 (1920).

[37] J. G. Davidson, "De-Tarring of Gas by Electrical Precipitation," *Dom. Can. Hon. Advisory Council for Sci. & Ind. Res. Rept.* No. 3 (1918).

[38] P. H. Moon and A. S. Norcross, "Three Regions of Dielectric Breakdown," *Jour. Amer. Elec. Eng.*, **49** [2] 125–29 (1930).

[39] W. L. Patrick and G. N. Peel, "Application of Fused Silica in Heating Processes: I, Furnaces and Heated Enclosures," *Ind. Chemist*, **12** [136] 221–26 (1936).

Moore[40] presents a table with curves showing the dielectric strength of transparent fused quartz and translucent fused silica at various temperatures and compares these with two grades of steatite and one of porcelain. He shows that fused silica in both the transparent and translucent forms is one of the best dielectric materials, and he attributes the lower insulating values of the translucent ware to the ionization of gas confined in the wall structure.

The radio-frequency phase difference angle of fused quartz is about 0.01° (36 seconds) at frequencies between 250 and 700 kilocycles per second. There is apparently little or no change in the radio-frequency phase difference and dielectric constant with frequency change. The specific inductive capacity of fused quartz is 3.5 to 3.6.

Important present-day applications of fused silica in electrical insulation include bushings for graphite compression resistance elements and, on a much larger scale, in the form of rings confining the mercury cathode pool in mercury-arc rectifiers. In both instances extreme temperature and electrical stresses due to arc-overs call for insulators of unusual properties.

XI. Optical Properties

The optical characteristic of fused quartz, which is of the most practical value in the arts, is its translucency to the shorter wave-lengths, a property in which it far excels any kind of glass. Lyman[41] mentions quartz, rock salt, and fluorite as the only substances occurring in masses of sufficient size that possess marked transparency in the ultra-violet. Fused quartz is somewhat less transparent than the crystalline material, but it is superior in this respect to any other substance which can be worked into the shapes required in the manufacture of lamps and reaction vessels for photochemical and similar purposes requiring the strongly actinic ultra-violet rays.

While individual specimens of fused quartz differ in their transparency in the ultra-violet region, about 2000 Å may be considered a practical limit of short wave-length transmission. Rayleigh[6] gives the limit of ultra-violet transparency of the translucent product, manufactured from sand, as about 2400 Å in pieces 5 millimeters thick. The clear quality of fused silica readily transmits ultra-violet radiations, visible light, and heat.

Unlike the crystal quartz used in its production, fused quartz usually becomes somewhat discolored by continued exposure to short ultra-violet rays, although with a considerably smaller percentage loss in transmission than is the case with so-called ultra-violet transmitting glasses. Like such glasses, the discoloration is removable (with restoration of impaired ultra-violet transmission) by heat treatment. A direct comparison is not practical, because the regions of the spectrum and the temperatures involved differ materially.

Baly,[42] in discussing this phenomenon, mentions the green phosphorescence which results when discolored fused quartz is heated in a powerful blast lamp. He finds that when the phosphorescence has disappeared under continued heating, the ware is again colorless and transparent to ultra-violet radiations.

Owing to internal reflection, light will pass apparently undiminished in intensity and unaltered in color through a considerable length of fused quartz rod, following the contour of the rod through curves which are not too sharp.

In addition to the data published by various investigators relative to the optical properties of transparent fused quartz under normal conditions, reference is made to the papers by Filon and Harris[43] on its photoelastic dispersion and by Austin and Pierce[44] on the variation of refractive index with temperature.

XII. Optical Applications

Arnulf,[45] after studying the deformation of glass and of fused quartz under variations of temperature, concludes that the latter is ideal for constructing standard flats and mirrors. For

[40] Burrows Moore, "Properties of Fused Silica," *Jour. Soc. Chem. Ind.* [London], **55** [8] 31–37T (1936); *Ceram. Abs.*, **15** [9] 272 (1936).

[41] Theodore Lyman, Spectroscopy of the Extreme Ultra-Violet, pp. 15–17. Longmans, Green, & Co., New York, 1928.

[42] E. C. C. Baly, "Photosynthesis," *Ind. Eng. Chem.*, **16** [10] 1016–18 (1924).

[43] L. N. G. Filon and F. C. Harris, "Photo-Elastic Dispersion of Vitreous Silica," *Proc. Roy. Soc.* [London], **A130** [813] 410–31 (1931).

[44] J. B. Austin and R. H. H. Pierce, Jr., "Determination of Refractive Index of Vitreous Silica and Calibration of Silica Refraction Thermometers between 18° and −200°C," *Physics*, **6** [1] 43–46 (1935); *Ceram. Abs.*, **14** [6] 135 (1935).

[45] Albert Arnulf, "Comparison of Deformation of Glass and of Fused Silica under Influence of Variations of Temperature," *Rev. d'Optique*, **6** [8] 316–27 (1927); *Ceram. Abs.*, **7** [10] 675 (1928).

refracting systems, he stresses the superior thermal conductivity of fused quartz, but he mentions the difficulty of obtaining optical homogeneity in pieces of appreciable size.

Thomson[46] mentions the following advantages of fused quartz for astronomical mirror blanks:

"Disks require but little annealing, while with the large glass disks this is a matter of great difficulty.

"They can be rough-ground without danger of fracture, an operation difficult with glass and rarely resorted to.

"The disks can be made very thick and rigid more easily than with glass.

"The fine grinding, or smoothing before polishing, is carried on with great facility, and the surface before polishing is usually of finer grain than glass. The fused silica is considerably harder than glass and not so easily scratched.

"The polishing proceeds readily and can be carried on regardless of temperature changes. Incidentally, there is less liability of scratches forming in polishing.

"In very accurate work, figured by polishing, as in high-grade surfaces of astronomical mirrors, the polishing and testing need not be interrupted (as by glass) with long rest periods with the mirror disk kept jacketed in felt for equalization of temperature. This is very important and involves great saving of time.

"In service none of the precautions against temperature variations and distortions arising therefrom is needed, and, even in solar work with full sunshine on the mirrors, no evil results follow.

"The silvering of surfaces of fused silica appears to be no more difficult than with glass, with the advantage, however, that the former can be warmed without risk when such warming is needed to assist the formation of the silver deposit."

XIII. Manipulation

Shenstone's description[47] of the manipulation of fused silica in the oxygas flame will be of interest to workers who wish to close or bend fused silica tubes or to carry out other simple operations before the blowpipe with this material. In some respects, fused silica is more easily worked in the flame than any kind of glass, as the piece may be suddenly thrust into the flame, or removed from it, and heated unequally without cracking.

A much hotter flame than that required for glassblowing is of course necessary for the manipulation of fused silica, and it has been found that a temperature of about 2200°C gives the best results; the oxyacetylene burner, however, affords too high a temperature with consequent volatilization of the silica. While in the molten condition, silica, unlike glass, will not flow readily into the desired shape, but must be pushed into place.

Twyman, Parker, and Dalladay[48] find that optically ground surfaces of fused silica, placed together in optical contact and subjected to carefully controlled heating, will unite and become one piece at temperatures below those which would produce devitrification and much below the melting point of the material.

XIV. Use in Ceramic Mixtures

In recent years, increasing interest has been shown in the possibilities of ground fused silica, either by-product material or specially prepared, as an ingredient in ceramic mixtures. A body possessing the low-expansion characteristics of fused silica but of a porous nature may be produced by bonding fused silica grains with gelatinous precipitated silica.[49]

Bauml[50] investigated the behavior of various forms of silica in porcelain mixtures but at the firing temperatures used, 1300° to 1600°C, he found no essential superiority in lowered shrinkage, etc., in the bodies containing fused quartz. He reports much greater reaction, however, with the other ingredients in the case of fused quartz as compared with crystalline quartz.

Moore[51] reports that "in proper proportions and with a suitable clay mixture, fused quartz will produce a highly refractory sagger, capable of withstanding considerable pressure at high temperatures and . . . . . particularly free from dunting through uneven heating or cooling." He was particularly successful in saggers for china-biscuit firing up to cone 9; others reported failures of saggers containing fused silica apparently due to use at higher temperatures.

Westman[52] has given the most complete ac-

[46] Elihu Thomson, "Mechanical, Thermal, and Optical Properties of Fused Silica," *Jour. Franklin Inst.*, **200** [3] 313–25 (1925); *Ceram. Abs.*, **5** [12] 390 (1926).

[47] W. A. Shenstone, Methods of Glass Blowing and of Working Silica in the Oxy-Gas Flame, pp. 84–95. Longmans, Green, & Co., London, 1913.

[48] Frank Twyman, R. G. Parker, and A. J. Dalladay (Adam Hilger, Ltd.), "Improvements in Joining Together Glass Surfaces," Brit. Patent 103,233, Jan. 18, 1917.

[49] W. W. Winship (The Thermal Syndicate, Ltd.), "Composition of Matter and Method for Making the Same," U. S. Patent 1,587,057, June 1, 1926.

[50] Fritz Bauml, "Studien über das Verhalten Verschiedener Formen von Kieselsäure in Porzellanmassen," (Thesis) München, 1912.

[51] B. J. Moore, "Some Notes on Saggars," *Trans. Ceram. Soc.* [Eng.], **20,** 93–104 (1921); *Ceram. Abs.*, **1** [3] 71 (1922).

[52] A. E. R. Westman, "Use of Fused Silica as a Raw Material in Manufacture of Porcelain," *Jour. Amer. Ceram. Soc.*, **11** [2] 82–89 (1928).

count to date of the effect produced by substituting fused silica grains for (Ottawa sand) flint in porcelain bodies. The new bodies, for which he suggests the name "fusilain" to distinguish them from "porcelains" in which crystalline silica is used, have distinctive properties, especially a lower maturing temperature and decreased thermal expansion.

Westman reports quite different results with fused silica bodies fired under oxidizing conditions and those produced under reducing conditions, the latter being much less porous. He found that although his firing temperature was appreciably above the nominal devitrification point of fused silica, no crystallization of the latter was apparent. Similar information has come from other users of fused silica in ceramic bodies, implying that in such mixtures fused silica does not readily crystallize despite the presence of fluxes which might be expected to promote devitrification.

Yoshioka,[53] in investigating the thermal expansion of fired clayware, found that the substitution of fused or precipitated silica for quartz gave low and regular expansion over wider ranges of heat treatment.

XV. Possible Use in Glasses

Investigations by Greig[54] of the Geophysical Laboratory hold out little promise for the commercial production of highly siliceous glasses containing a small percentage of other oxide. It would be expected that such glasses, while melting at lower temperatures than vitreous silica would still have very low expansions and perhaps a lessened tendency to crystallize, thus increasing their useful temperature range.

It was found, however, that in two-component mixtures, each containing 90% or more of silica, at about 1700°C, calcium, magnesium, strontium, iron, manganese, cobalt, nickel, and zinc oxides are not completely miscible with silica in the liquid state. The oxides of boron, sodium, potassium, aluminum, barium, tin, and beryllium will give clear glasses under similar conditions, but the resulting glasses from soda, potash, and boric oxide are readily attacked by water, while cristobalite separates from the highly siliceous barium glass. Glasses containing possibly 5 to 10% of alumina, beryllia, or stannous oxide alone seem to possess technical possibilities.

Bannister[55] recommends fused quartz as the most suitable "parent substance" in the manufacture of artificial (silicate) gems.

XVI. Vitreous Silica Minerals

Despite the enormous variety and great abundance of the silica minerals, vitreous silica is of rare occurrence in nature. This fact is readily explicable by the high temperatures required for its formation. The natural forms of vitreous silica, included under the general name of "lechatelierite" have usually been due to the fusion of silica sand by a chance stroke of lightning or in rarer cases to the vitrification of silica by the heat generated through the impact of a meteor.

The lightning-formed fusions, known as fulgurites, constitute irregularly shaped tubular masses and are generally found in desert regions although Petty[56] has recently described their rather plentiful occurrence in various sections of North and South Carolina.

Spencer[57] gives an interesting description of natural fused silica found in various parts of the world as a phenomenon accompanying meteorite craters where the surrounding rocks are highly siliceous, such as quartz sand or sandstone.

He emphasizes the formation of these craters, not by the mere projectile force of the meteorites, but by the explosive force of sudden vaporization of part of the meteorite and the surrounding earth through intense heat due to the meteorites' impact. Under the enormous pressures due to this impact, the boiling point of the silica forming the natural glass was no doubt much higher than the commonly used figure of 2590°C.

Spencer mentions silica glass as present at the meteorite craters of Wabar in the Arabian desert, Arizona, Henbury in Central Australia, and probably of Campo del Cielo in Argentina. That from Wabar he finds quite unusual, a great

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[53] Tokasu Yoshioka, "Thermal Expansion of Fired Clay Ware," *Proc. World Eng. Congr.* [Tokyo, 1929] **31,** 435–51 (1931); *Ceram. Abs.*, **11** [9] 503 (1932).

[54] J. W. Greig, "Immiscibility in Silicate Melts," *Amer. Jour. Sci.*, [5] **13** [73] 1–44; [74] 133–53 (1927); *Ceram. Abs.*, **6** [4] 157 (1927).

[55] F. A. Bannister, "Relation between Density and Refractive Index of Silicate Glasses, with Application to Determination of Imitation Gem-Stones," *Mineralog. Mag.*, **22** [126] 136–54 (1929); *Ceram. Abs.*, **9** [5] 342 (1930).

[56] J. J. Petty, "Origin and Occurrence of Fulgurites in the Atlantic Coastal Plain," *Amer. Jour. Sci.*, [5] **31** [183] 188–201 (1936).

[57] L. J. Spencer, "Meteorite Craters as Topographical Features on the Earth's Surface," *Smithsonian Rept., 1933,* pp. 307–25.

quantity of masses of cindery and slaggy structure as well as bomb-like specimens having been discovered. Some of the latter are quite small and are described by the author as "black pearls."

The bombs are very light in weight with an internal structure of white cellular silica glass, the thin outer skin of black-appearing glass proving to be brown and transparent and containing only a few small bubbles when examined microscopically. The outer skin contains iron and some nickel. At the high pressures and temperatures involved, Spencer believes that iron and nickel were probably vaporized and that a shower of molten silica was projected through this mixed vapor. Certain specimens of vesicular silica glass from Wabar he estimates to contain up to 2,000,000 tiny polished spheres of nickel-iron per cubic centimeter, ascribing these formations to minute condensed spheres of meteoric iron falling back into a pool of boiling silica.

Spencer describes the silica glass from the Arizona crater as "more like a sintered sandstone, not showing the effect of complete fusion, as at Wabar." The Henbury material, formed from ferruginous sandstone, is less pure. The transparent glass at the Argentine crater has not yet been fully examined. The glasses from the Wabar, Arizona, and Henbury craters are intimately mixed with meteoric iron.

Quite an extraordinary deposit of natural silica glass in the Libyan Desert has been recently explored and described by the same author, although there is no conclusive evidence that this particular deposit is of meteoric origin. Clayton and Spencer[58] have published an account of this mineral, which is found over quite a wide area and in lumps up to ten pounds in weight.

Some fragments show evidence of hand-chipping into crude tools probably by paleolithic man, many thousand years ago. The glass is of high purity for lechatelierite, some specimens being quite clear and only slightly discolored and running as high as $97^1/_2\%$ silica. One specimen, cut for the British Museum, has a specific gravity, refractive index, and optical dispersion closely agreeing with pure fused quartz. Although produced by the fusion of sand, bubbly structure is not marked in all specimens, and recrystallization is not commonly found, giving new evidence of the permanence of the glassy condition of silica over long periods.

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[58] P. A. Clayton and L. J. Spencer, "Silica-Glass from the Libyan Desert," *Mineralog. Mag.*, **23** [144] 501–508 (1934); *Ceram. Abs.*, **13** [7] 191 (1934).

WASTE IN DRYING*

BY M. W. BLAIR

ABSTRACT

The waste of power, fuel, and products in drying structural clay products, due to obsolete equipment and careless operation is discussed, and the possibilities of actual cash savings in operation and regulation are suggested. Examples of construction and operating absurdities are cited.

I. Introduction

Waste-heat driers of the tunnel type, for which the heat used is a by-product of some other process in the plant, are outstanding in three types of waste, *viz.*, power, fuel, and loss of ware.

Power losses occur in driving oversize and obsolete fan equipment, *i.e.*, in moving heavy equipment to perform a comparatively small amount of work. They occur in driving air through badly designed and undersize ducts in which restricted openings and right-angled turns impose a tremendous but unnecessary friction load. The measure of these losses is almost impossible to take or compute, owing to the fact that no two driers and kiln layouts present the same conditions as to size or length of flues and no two present the same resistance in internal distribution or ware arrangement. Experience, however, has fully demonstrated that a common-sense correction of the obvious objectionable features has resulted almost invariably in a power reduction of 50%, with a noticeable improvement in production and quality of ware.

Some installations, which only a few years

* Received March 1, 1937.

ago were considered to be the last word in design for handling waste-heat drying, have yielded 65% of their power costs to recent overhauling.

II. Losses Cited

In recent months, one or more of the following conditions were found in as many different driers which were not giving satisfactory results:

(1) There was a temperature variation of 75°F from tunnel to tunnel on the discharge end, owing to absence of control dampers on the individual tunnels.

(2) A solid brick wall blocked the cold-air inlet to steam radiation which was expected to supply heat for drying.

(3) In five tunnels of fifteen, the ceiling had been partially removed; the condition had existed for five years.

(4) One tunnel of nine had no connection to flues leading to the exhaust fan and therefore no circulation.

(5) In a goose-neck system for reclamation of waste heat, fire boxes within six feet of the goose-neck opening were wide open and the end of the goose neck was jambed tight against the brick setting; there was practically no heat to the drier after the first three or four hours.

(6) Doors on both receiving and discharge ends of driers were in such condition as to rob hot air on one end and effectually damper the exhaust on the other.

(7) A 60-inch propeller-type exhaust fan was discharging against a perpendicular baffle 24 inches from the face of the propellers.

(8) More than 100 tons of waste and rubbish were found in a 19-track drier, effectually blocking air circulation.

(9) Fan installation gave increased power consumption and heavy friction losses in circulation (see Fig. 1).

(10) A drier was constructed with the expectation that the moisture exhausted would condense in overhead flues and be carried off as liquid by means of drainage ditches and down-spouts provided in the structure.

(11) Propeller fans were installed to produce vertical circulation but were not provided with concentrating rings or housings, resulting in a recirculation from tips of blades through the center of the fan instead of through the ware.

(12) Hacking methods and arrangements of ware on drier cars were found, which allowed a maximum of free air travel instead of a minimum; thus hot gases missed the ware they should have dried which caused breakage and distortion.

(13) A 10-foot, centrifugal-type fan in connection with a 20-track waste-heat drier was found to be running backward since its installation (sixteen years previously); unnecessary auxiliary heat was poured into it. In fuel, power, and inefficiency, it would be a conservative statement to say that the waste, in this instance, has more than equaled the entire original cost of the plant.

The foregoing examples show uncorrected conditions which render driers inefficient and result in lowered production, lack of uniformity in dried ware, waste of fuel in watersmoking, loss in handling semidried ware, increase in kiln marking, cullage due to uneven size and objectionable

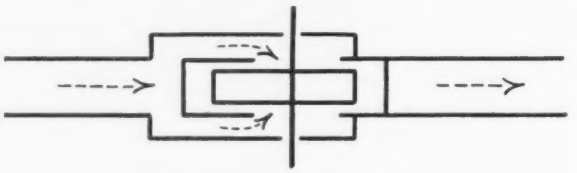


FIG. 1.

color, and waste of expensive coloring agents. All are insidious losses which are difficult to trace and appear on the books only when there is a sale of "specials" at ruinous prices or a heavy inventory of seconds and culls.

In addition to these wastes, which are noticed only as they appear in the final products, are the wastes in power and in damaged ware which are returned as raw material or are hauled to the dump.

III. Power Waste of Fans

Paddle-wheel or multiblade fans in waste-heat driers are obsolete. The rotation of a heavy mass of metal on large shafts in plain bearings, inefficient belt drives, sudden right-angle turns in air flow, and impingement against obstructing walls, cut the mechanical efficiency of such installation to 35 or 40%. On the other hand, the propeller fan, direct-connected or V-belt driven, mounted on short small-diameter shafts running in ball or roller bearings, has a mechanical efficiency of 65 to 75%. By placing the fan directly in the tunnel, eliminating short turns, baffles, and high pressures, the total power saving amounts to an average of 50%.

Few operators realize that the "24-hour-per-day, 30-day-per-month operation" of a drier fan can easily amount to more than the other power costs of the entire plant. At two cents per kilowatt hour, the substitution of a 10 horse-power unit for one requiring 20 horse power effects a power saving alone of $107.40 per month. A savings of 15 horse power ($153 per month) has not been uncommon. If the necessary investment on such a substitution is taken at $1000,

the carrying charge would be $160 per year, with interest at 6% and depreciation at 10% and, on ten months' operation, the net returns would be $1370 or 137%. Replacement of some of the more modern types of centrifugal fans have shown slightly less return than the example given, but in no case on record has the saving been less than 40%.

IV. Long-Distance Movement of Air

Another source of power waste is lack of regulation and movement of cold air over unnecessarily long distances. It requires 1 horse power to move 6370 cubic feet of air per minute against a static pressure of one inch of water. It can be seen that the common practice of kicking the cover off a manhole at a distant kiln or of leaving a cold kiln on the fan to reduce temperature is expensive guesswork. If only 6370 cubic feet of air is thus hauled to the drier, the cost for ten months' operation would be 24 by 746 by 30 (537 kilowatts per month or 5340 kilowatts per year) which, at 2 cents, amounts to $106.80. The same type of waste occurs when the drier fan is used to cool the kilns. A 1 horse-power motor at the kiln will handle 14,500 cubic feet of free air per minute or give 2.2 times the service for the same amount of money.

To avoid this expense an automatic Louvre and temperature regulator is installed at the fan. The investment is $400; the annual cost $64, a net saving of $42.80 in power for every 7000 feet per minute so handled. This does not take into account the time of the foreman or superintendent in watching the thermometer or adjusting manhole covers or the losses due to irregular temperature which will be considered later. Thus far, the amounts are not large; the total is about $1500 per year per 100 tons daily production and 10 months' operation. But if the cost of taxes or insurance of any clayworking plant were raised $1500 per year, there would be considerable objection.

V. Drying Efficiency of Air

Another serious waste is the failure to obtain maximum drying efficiency from the air used, which makes it necessary to handle two or three times as much air as actually required to do the work. To remove and carry from a drier 20% moisture or 400 pounds from one ton of clay in usual brick and hollow-ware dimensions in 24 hours (supposing air to leave the drier at 100° and 70% saturation), it would carrry out 13.38 grains per cubic foot less what it carried in when picked up at the kiln. At 60°F and 60% humidity (3.49 grains or a net of 9.89 grains per cubic foot), to remove one pound, under these conditions, would require $\frac{7000}{9.89}$ or 700 cubic feet. To dry one ton or to remove 400 pounds of water would require 280,000 cubic feet in 24 hours or 194 cubic feet per minute. To dry 100 tons or remove 20 tons of water would require 194×100 or 19,400 cubic feet per minute.

In a waste-heat drier which approached this figure, the fan equipment is a 3 horse-power 48-inch single propeller with a rated capacity of 20,000 cubic feet at $^3/_4$ inch static pressure. For ten years this drier has been drying 30,000 soft-mud brick per day.

There are hundreds of driers equipped with 10- and 12-foot paddle-type fans, running at from 90 to 120 r.p.m., requiring from 15 to 35 horse power and delivering from 60,000 to 100,000 cubic feet of air per minute but drying only 90 to 300 tons per 24 hours. There are hundreds of driers equipped with multiblade fans from 6 to 10 feet in diameter, running from 160 to 100 r.p.m., requiring from 13 to 40 horse power to deliver the same amount of air and to effect about the same amount of drying.

The necessity for the surplus air delivery is due to improper flues, inefficient circulation, and slow pick-up of moisture, with the result that the air is removed from the drier without its proper load of vapor, and the humidity of the discharged air drops as low as 50% or less.

VI. Drying as a Function of Temperature

There is a prevalent theory that a low temperature and large volume produces the best drying condition. This is a fallacy. The facts are that better drying conditions are obtained with higher temperatures if the humidity is correspondingly high. It requires larger volumes of air at lower temperatures to carry the necessary heat to cause evaporation. Drying is a function of temperature. Circulation is necessary only to carry away the evaporated moisture, but the evaporation would be infinitely slow if there were no difference in temperature between the air and the ware.

Obviously it is a waste to put 60,000 feet of air

per minute through a drier when 20,000 will do the work. It can be shown that calculations check, whether the problem be considered from the viewpoint of carrying the necessary heat or of moisture removal.

The tendency for air to leave a drier only partially loaded to capacity is caused (1) by lack of contact with the moist surfaces, due to the absence of cross and vertical travel, to the obstruction imposed by the ware itself, and to pocketing in improperly hacked ware, and (2) by lack of time due to the rapid passage of the air through open and free spaces from one end of the drier to the other. If the velocity of moving air created by pressure is considered, it can readily be seen why the air races over the top and sides of a drier car. If the pressure is only 0.1 inch and the temperature 200°, the velocity of dry air will be 1400 feet per minute and will travel through a 100-foot drier in four seconds. If that pressure is increased to 1 inch, the velocity increases to 4470 feet per minute. It is more than 4000 feet at any temperature above 70°, or it will travel at that pressure through a 100-foot drier in $1^1/_2$ seconds, which is very little time in which to lay down heat or pick up water.

VII. Recirculation of Air

As the volume delivered by a centrifugal fan varies directly as the speed, the pressure as the square, and the power as the cube, to avoid waste of power, we should more nearly approach the actual requirements in the amount of air handled and expend some of it in rehandling the same air in order to load it efficiently.

A new drier should be designed with recirculation in mind, and the necessary ducts provided as part of the original construction. It can be accomplished in existing driers by construction of overhead or underground flues, either leading to the intake of the induction fan or by the installation of small low-powered independent fans. There are two objectives in recirculation: one is to increase the efficiency of the air handled by loading it uniformly; the other is to produce a safe drying medium to avoid waste in cracked and blistered ware.

VIII. Costs Involved

The value of a product once in the setters' hands is not less than $3.00 per ton. At this figure, a loss of 1% on a 100-ton plant amounts to $1000 per year which will pay the interest and depreciation on an expenditure of $6250. The profit would be on the additional daily ton of marketable ware produced, which probably would not be more than $150 per year plus the cost of disposing of the waste. Suppose, however, that this loss runs as high as 5% and it is possible to save only one-half of it, then the return would be $7.00 per day ($2100 per year), which would allow the $6250 investment and show a gain of $1100 in reduced cost, an additional profit of $450 per year on the extra $2^1/_2$ tons a day produced plus the cost of disposal of that much waste. It is also fair to presume that a drier condition which produces 5% that is actually rejected by the setting crew, produces another 5% that goes into seconds or culls which they never see at all but when finished must be marketed for less than the cost of manufacture.

2131 South Center Street
Terre Haute, Indiana

ABRASIVE ACTION OF SEWAGE ON BRICK SEWERS*

By Harry C. Plummer

Abstract

This paper presents data obtained in the inspection of three brick sewers constructed in Cleveland approximately fifty years ago. The brick in the invert were inspected for erosion, and brick samples were taken from the sewer and were tested for absorption, compressive strength, and modulus of rupture. A review of known similar investigations is also given.

I. Introduction

The first complete sewerage system to be constructed in the United States was designed and built by E. S. Chesbrough for the city of Chicago in 1858. The Chicago sewers, more than 24 inches in diameter, were constructed exclusively of brick until the latter part of the 19th Century. The first large-size concrete sewers to be constructed in America were built in Washington, D. C., in 1885. These sewers were lined completely with brick.

It would be difficult to estimate the total miles of brick sewers now in use in this country. In response to a questionnaire sent in 1935 to the sewer departments of the one hundred largest cities in the United States, forty-four cities reported a total of 5924 miles of brick sewers then in use (see Table I). A large percentage of these sewers are now more than thirty years old.

Table I

Result of Survey Conducted by the Brick Manufacturers Association in 1935

City and state	Total length brick sewers (miles)
Akron, Ohio	49
Baltimore, Md.	148
Bronx, N. Y.	11
Brooklyn, N. Y.	193
Canton, Ohio	20
Chattanooga, Tenn.	14.2
Chicago, Ill.	2300
Columbus, Ohio	100
Dallas, Texas	3
Dayton, Ohio	15
Detroit, Mich.	350
Fall River, Mass.	23
Flint, Mich.	2.25
Fort Wayne, Ind.	20
Hartford, Conn.	50
Jersey City, N. J.	76.5
Los Angeles, Calif.	22.11
Lowell, Mass.	25.5
Minneapolis, Minn.	106.3
Nashville, Tenn.	52
Newark, N. J.	69
New Haven, Conn.	44.41
Oklahoma City, Okla.	0.5
Philadelphia, Pa.	1600
Pittsburgh, Pa.	90.8
Portland, Ore.	18.9
Providence, R. I.	105
Queens, N. Y.	10
Richmond, Va.	79.94
Rochester, N. Y.	20.5
Sacramento, Calif.	5.6
Salt Lake City, Utah	7
San Francisco, Calif.	30
Scranton, Pa.	15
Seattle, Wash.	19.68
Spokane, Wash.	0.2
Syracuse, N. Y.	35
Tacoma, Wash.	0.23
Toledo, Ohio	153.3
Tulsa, Okla.	2.627
Wichita, Kans.	12
Wilkes Barre, Pa.	3.5
Wilmington, Del.	5.3
Youngstown, Ohio	15
Total	5924.34

Table II

Weighted Averages of Strength and Water Absorption for Hard Brick*

City	Av. compressive strength (lb./sq. in.)	Av. modulus of rupture (lb./sq. in.)	Av. water absorption (%) 5-hr. boil
Boston, Mass.	8240	1360	10.6
Hudson Valley	4740	745	17.7
Baltimore, Md.	5990	1330	12.3
Philadelphia, Pa.	6580	855	14.5
Pittsburgh, Pa.	11060	2055	7.7
Cleveland, Ohio	9820	1185	11.1
Detroit, Mich.	4330	900	19.5
Chicago, Ill.	3450	1265	19.0
St. Louis, Mo.	11040	1465	9.1
Denver, Colo.	5050	620	13.5
Los Angeles, Calif.	3690	600	14.2
Richmond, Va.	9350	1315	11.1
Washington, D. C.	5700	875	12.9

* See footnote reference 1.

There are few records that indicate the quality of the brick used in the construction of these old sewers, but such as are available show that, as a rule, they were constructed of the common brick produced locally.

J. W. McBurney,[1] in reporting strength, water

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 23, 1937 (Structural Clay Products Division).

[1] J. W. McBurney and C. E. Lovewell, "Strength, Water Absorption, and Weather Resistance of Building Brick Produced in the United States," *Proc. A.S.T.M.*, **33** [Part II] 636–50 (1933); *Ceram. Abs.*, **13** [4] 88 (1934).

absorption, and weather resistance of building brick produced in the United States, lists averages from thirteen principal cities and twenty-six districts (see Table II). Of the cities reported, the lowest absorption by five-hour boil are Pittsburgh brick with 7.7%, and the highest are Detroit brick with 19.5%. The average for the thirteen cities is 13.3%.

It is therefore probably safe to conclude that the majority of brick sewers constructed in this country prior to 1900 were built of brick having an absorption (five-hour boil) of more than 10%.

Relatively few people ever see the inside of a sewer after it is constructed. Few engineering structures receive less attention or are inspected less frequently. Consequently, data regarding the abrasive action of sewage and the erosion of sewer inverts are surprisingly scarce, and discussions of this subject are more often based upon theoretical considerations than upon actual performance records.

II. Review of Investigation

One of the most extensive investigations of the wear on sewer inverts, of which there is a record, was conducted during 1909 and 1910 by Metcalf and Eddy,[2] sanitary engineers of Boston, who inspected the brick sewers of Worcester, Mass. Brick samples were taken from some of the sewers, of which the following are typical:

(*a*) Brick taken from a 30- by 45-inch egg-shaped section built by contract in 1874. The masonry of this sewer was constructed of two rings of sandstruck brick of 20 to 30% absorption, laid in Rosendale cement mortar. The brick were taken from a section where the grade is 6.94%. The velocity in this section (based on Kutter's formula, $n = 0.015$) at two-thirds full is 22 feet per second.

The upstream ends of the brick were worn more than the downstream ends. In some instances, the downstream ends were worn off 2 to $2^1/_2$ inches. The mortar was very sandy and comparatively soft and had been washed out for a considerable depth below the surface of the brick.

(*b*) Another sample was taken from a 48- by 72-inch egg-shaped section, built in 1872 by contract, of 8-inch brickwork laid in Rosendale cement mortar. These brick were taken from the invert on a section where the grade was 2.9%, and the estimated velocity flowing two-thirds full was 20 feet per second. The brick were very hard and dense, probably having an absorption of 8 to 12% and were worn very smooth almost to a polish. The small end in each case was the upstream end. In some instances, $1^1/_2$ to 2 inches had been worn off at the upstream end of these brick.

Regarding the Worcester sewers, the investigators state:

> "The brick invert was found to be badly worn in all sections where the velocity flowing two-thirds full exceeded 8 or 9 feet per second, estimated by Kutter's formula with $n = 0.015$. In some sections, where the estimated velocity amounted to 12 or 13 feet per second, the first course of brick in the invert was worn through in places, and the second course was partly worn."

The same investigators, however, on a similar investigation conducted at Louisville make the following statement:

> "It is interesting to compare the experience gained at Worcester with information obtained at Louisville from an inspection of old brick sewers. Where the velocity was high, there was but little wear of the brick, while at Worcester sewers having apparently the same velocity showed serious wear. The explanation is that at Worcester the street detritus contained a large quantity of quartz sand coming from streets which for many years were surfaced with gravel. There were also large deposits of sand and gravel in the city, and the soil as a whole contained a large amount of quartz. In spite of the large number of catch-basins in use, considerable quantities of sand and gravel entered the sewers and, as the detritus was carried along by the flow of sewage, the invert brick were worn by the harder material. At Louisville, the soil is composed of clay and disintegrated limestone, and the streets were surfaced with crushed limestone which, for the most part is softer than the sewer brick. Even in sewers constructed of relatively soft brick, those testing between 24% and 30% absorption, there appeared to be but little wear from the velocities which at Worcester had caused serious wear. Although doubtless the detritus washed along the inverts at Louisville caused some wear, the attrition was much more effective upon the detritus itself than upon the sewer brick."

A report of the Metropolitan Sewerage Commission of New York contains the following statement regarding the erosion of sewer inverts.[3]

> "Few cases where the brick of the invert were actually worn away were found. In a few places in the upper west side of Manhattan, the upstream edges of the brick were

[2] Metcalf and Eddy, American Sewerage Practice, Vol. I, 2d ed., p. 452. McGraw-Hill Book Co., Inc., New York, 1928.

[3] Report of the Metropolitan Sewerage Commission of New York, published in 1910, page 536. 550 pp.

rounded off as a result of high velocity of sewage. In a large number of sewers, the mortar was worn from the joints in the brickwork of the invert. Sometimes the mortar has been worn away only to a slight depth while at other places it has been cut out by the sewage to the full depth of the brick."

E. A. Herman, in 1904, reported on the effects of abrasion on the sewers in St. Louis. The sewers inspected were combined sewers on grades ranging from 0.2 to 2.0%, averaging about 0.5% for sewers more than 5 feet in diameter and about 1% for those of smaller sections. Mr. Herman reports that vitrified clay pipe showed no appreciable wear after about 35 years' use; vitrified brick inverts showed no appreciable wear after about 12 years, the oldest vitrified brick sewers inspected; and inverts of ordinary sewer brick showed some wear after about three years and from two to four inches wear after a use of 30 years.

The absorptions of vitrified brick and ordinary sewer brick, as referred to by Mr. Herman, are not given in his report. Vitrified brick, however, are described by him as "building foundation vitrified brick."

During the early part of 1937, the James H. Herron Company, Cleveland, Ohio, inspected three brick sewers in Cleveland for the Brick Manufacturers Association of America. All of the sewers inspected are combined sewers. A summary of the report of these inspections and of the test conducted on brick samples taken from the old sewers is given.

Test No. 1

A sample consisting of six whole brick was taken from the East 14th Street sewer, approximately 100 feet south of Scovill Avenue. The overlying pavement consists of brick laid directly on compacted earth. The original pavement was apparently filled with cement grout, but subsequent repairs have been made using bituminous filler. Traffic includes numerous heavily loaded trucks bound for the adjacent market district and trucking terminals.

The sewer at this point is egg-shaped, 27 by $23\frac{1}{4}$ inches inside dimensions, and is constructed of a single ring of common brick, 4 inches thick. The sewer is 16 feet below grade in sandy soil and has been in service for 55 years. The grade of the section inspected is 0.4%, and the estimated maximum velocity is 4.45 feet per second.

Tests of five whole brick taken from this sewer gave an average absorption (5-hour boil) of 18.6%, an average compressive strength on edge of 3759 pounds per square inch, and an average modulus of rupture of 709 pounds per square inch.

Regarding the condition of the brick, the report states:

"The inner faces of the brick were not badly worn and, in general, the brick appeared to be in good condition.

"A manhole, constructed at the same time as the sewer, was also inspected; the condition of the brick was noted to a depth of 4 feet below grade. No evidence of disintegration on the part of the brick was noted. When tested by blows of a hammer, the brick appeared to be as hard as those taken from the sewer. Mortar between the brick had worn away through the action of water and frost, in some places to the depth of one inch. That remaining in place could be readily removed with hammer and chisel."

Test No. 2

A sample consisting of five brick was taken from the East 66th Street sewer at the intersection of Hough Avenue. The overlying pavement is sheet asphalt. Traffic is principally fast-moving passenger cars but also includes some medium-weight trucks.

The sewer is egg-shaped, 27 by $23\frac{1}{4}$ inches inside dimensions, constructed of common brick, 4 inches thick above and 8 inches thick below the spring line. The sewer is 25 feet below grade and has been in service for 57 years.

The grade of the section inspected is 1.5%, and the estimated maximum velocity is 8.84 feet per second. This sewer connects with a larger sewer built in 1876.

Tests of five brick taken from the sewer gave an average absorption (five-hour boil) of 17.8%, an average compressive strength on edge 2860 pounds per square inch, and an average modulus of rupture 726 pounds per square inch.

Regarding the condition of the brick, the report states:

"The sewer south of Hough Avenue was carrying water to a depth of 8 inches when inspected. The brick therein appeared to be in good condition. No large cracks were noticed, and no abrasion was evident on the brick and mortar above the water. The ease, however, with which brick comprising the sample were removed indicated a weak bond between the mortar and brick. Brick taken from the lower part of the sewer from beneath the running water were worn on the inner exposed base, but not sufficiently to weaken the structure. The wear was estimated at not exceeding 0.05 inch average depth, except at the exposed ends, where water and sludge cascaded

from the smaller into the larger sewer. Measurements of the wear on these brick follow:

Brick No. 3 worn from 0.30 inch to 0 in 1.0 inch.
Brick No. 4 worn from 0.28 inch to 0 in 2.0-inch length.
Brick No. 5 worn from 0.14 inch to 0 in 0.90 inch.

At this point the mortar between the brick was worn away to a depth of 1.10 inch for a distance of at least 8 inches."

Test No. 3

A sample consisting of five brick was taken from the Addison Road sewer. The overlying pavement is asphalt and the top of the sewer is 16 feet below grade. The sewer is circular in section, 9 feet inside diameter, constructed of three rings of common brick, 12 inches thick, and has been in service for 49 years.

The grade of the section inspected is 0.1% and the estimated velocity flowing half full is 5.42 feet per second.

Tests of five whole brick taken from this sewer gave an average absorption (5-hour boil) of 16.5%, average compressive strength 3667 pounds per square inch, average modulus of rupture 705 pounds per square inch.

Regarding the condition of the brick, the report states:

"Pitting was noted on a small area on the west side of the sewer about 10 feet south of the manhole. The depth of pitting was estimated not to exceed 1/8 inch. No other evidence of wear was noted on the brick, and no cracks were observed in the brickwork. In a few places in the lower part of the sewer, the mortar was worn out to a depth of 1/4 inch. Assuming routine maintenance, such as repointing where necessary, the sewer would be classed as in excellent condition. The brickwork of a manhole constructed at the same date as the sewer was also inspected and was found to be in good condition."

The data presented here are in accordance with the findings of other investigators and they indicate that, under conditions similar to those to which the sewers inspected have been subjected, hard-fired brick of relatively high absorption, when built into a sewer invert, will show no appreciable abrasion after a period of from fifty to sixty years.

Brick Manufacturers Association of America
2121 Guarantee Title Building
Cleveland, Ohio

THE CONSTRUCTION AND OPERATION OF A SIMPLE PYROMETER SYSTEM*

By Eugene C. Clemens

Abstract

For use with kilns firing sewer pipe, a pyrometer system must be rugged, simple, accurate, and resistant to corrosive gases. Low initial cost and economy of operation are desirable. Using a conventional wiring circuit, a base metal system was constructed having these features and was made of stock materials with the exception of three parts. Operating as high as cone 6, this system showed greater accuracy and lower cost than a noble metal system. Repairs are easily made. Wiring circuit, construction details, and operating life are given.

I. Introduction

During an investigation of means to improve the control of heat treatment while firing sewer pipe and flue lining, the pyrometer system then in use was found to be responsible for variations between kilns of fired ware.

A pyrometer system was built for a specific set of conditions, and the results of its use are described.

II. Previous Methods

At the time of this investigation, a common return system was being used connecting twenty-six kilns and using platinum thermocouples. The thermocouples of 22-gage wire were inserted in a porcelain tube connected to a standard make of head, and this assembly was inserted into a fireclay tube cemented in the kiln crown. Compensating lead wires connected the thermocouples to copper wire near the edge of the kiln, and these copper wires ran directly through a switch box to indicating and recording instruments wired in parallel. The instruments were provided with cold-end compensators.

The protecting tubes were not all projected through the under side of the kiln crown to the same depth, and nearly all of them extended above the top of the crown to a distance exposing

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 24, 1937 (Structural Clay Products Division).

about 6 inches of fireclay tube to the weather between the head cover and the flange holding the tube in place. The fireclay tubes frequently broke where they were exposed to the weather above the crown.

The head was made of die-cast metal with a rubber gasket and small brass fasteners, all of which were easily corroded by salt and sulfur fumes and made it difficult to dismantle the head for repairs or thermocouple replacements. Rain often leaked into the head. Moisture condensed in the porcelain tubes at times shorting the circuit, and the tube had to be removed and dried.

Owing to the relatively low millivoltage developed by this system during the early stages of firing, the indicator readings, as checked by a potentiometer, were often in error as much as 100°F.

The small-gage thermocouples were also easily damaged in handling.

Except for the cold-end compensator at the instrument, there was no correction for cold-junction temperatures.

In addition to these defects in the system, there were (1) nonuniform location of cold junction, (2) unequal lengths of compensating lead wire, (3) improper location of thermocouple in crown, and (4) faulty connections.

III. Development of Thermocouple Assembly

Because ware was fired to cone 6 at this plant and temperatures above 1800°F were maintained for 24 hours in the firing schedule, base metal was never considered to be practical.

The greater millivoltage developed by base metal as compared to platinum would permit greater accuracy, and the first step was the trial of base-metal thermocouples with all firing schedules.

Chromel-Alumel in all gages from 18 to 6 was tried; the 8-gage was found to be most practical. Eighteen-gage thermocouples lasted only one firing. Experiments on the 8-gage type were discontinued after eight firings with the thermocouple still sound. From past experience with platinum thermocouples, and comparing costs of platinum versus base metal, it was decided that the latter had to last only eight firings to be as cheap as the noble metal.

Having proved that the base metal was economical to use, the assembly shown in section in Fig. 1, was developed around the thermocouple. Strung with fireclay insulators, the thermocouple was housed in a porcelain tube, protected by a fireclay tube and covered with a cast-iron head and cap.

Patterns were made for the head, cap, and flange, which can be cast cheaply with no machining except drilling and threading three holes.

A steel bracket to support the lead wire by a standard porcelain insulator was fastened to the head by the bolt to hold the head to the fireclay tube. The cap sitting on the head was not fastened and could be lifted off to remove the thermocouple and the porcelain tube.

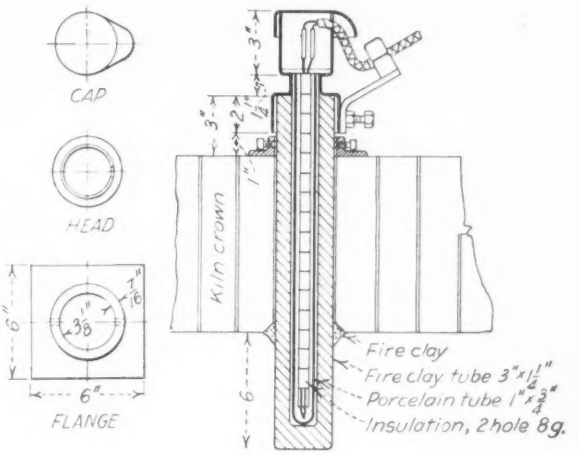


FIG. 1.

Trumbull or similar connectors fastened the lead wire to the thermocouple, the connectors being renewed with each new thermocouple.

The thermocouple wires projected through a transite disk sitting loosely in the head. The disk, in addition to centering the wires, protects the terminals from the heat rising from the porcelain tube.

Enough play was allowed in all parts for air to enter so that an oxide coating could form on the thermocouple. This coating gives the thermocouple longer life.

For better appearance and to prevent the cast iron from rusting, the flange, cap, and head were coated with a high-grade, heat-resisting cable paint.

By anchoring the fireclay tube to the kiln crown on the underside only and leaving it free to expand through the crown as it is heated, very little stress was placed on the tube. The porcelain tube was also free to expand when heated.

The head extending to the flange protected the fireclay tube from rain, snow, and freezing.

IV. The Wiring Circuit

No originality is claimed for the wiring circuit which has been described.[1] It is shown in Fig. 2.

The auxiliary thermocouple was placed in a position where the atmospheric temperature is the same as the cold-junction temperatures for all the kiln thermocouples, and the cold junction

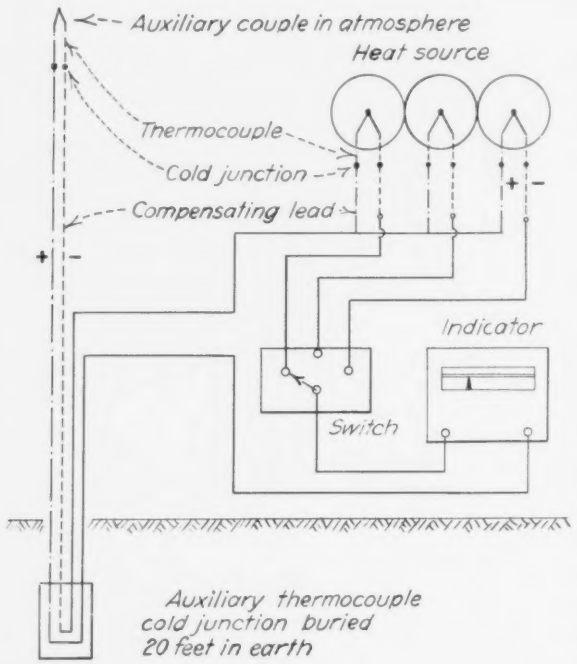


FIG. 2.

of the compensating thermocouple was buried in the ground where the temperature was constant.

When the system was installed, the pyrometers were set to read the temperature of the cold kilns. Variations in cold-junction temperature are compensated by the auxiliary thermocouple, and variations in temperature at the instrument are cared for by the cold-end compensator in the instrument.

All of the thermocouples have the same relative position in the kiln crowns; the cold junctions are uniformly placed with respect to the heat radiated from the kiln and heat from the atmosphere.

All connections are soldered and covered with tape. Where exposed to the weather, the wiring was bundled into a cable and covered with two wrappings of friction tape which, after wrapping, was painted with cable paint.

The system is operated by the fireman merely by turning the switch to the terminal connecting the desired kiln and reading the temperature from the indicator.

V. Results

The results from this system were better than anticipated. Due to the higher millivoltage developed, the elimination of cold-junction errors, and errors from faulty connections, the accuracy of the system was increased.

Schedules can be duplicated within 25°F, and the accuracy of the system as checked by a portable potentiometer is ±10°F.

The average life of the thermocouples is 30 firings or, at 2 firings per month, 15 months. The thermocouples are protected from salt fumes and combustion gases. Considering all costs both for the platinum and the base metal systems, the latter was considerably cheaper to operate.

VI. Conclusions

Designed for rough use under corrosive conditions, the system described is simple in principle, easy to operate, and sufficiently accurate for use in firing structural clay products.

The construction of the thermocouple assembly makes thermocouple changes easy. All parts are rugged and easily handled. Installation and operating costs are lower than those for the platinum system.

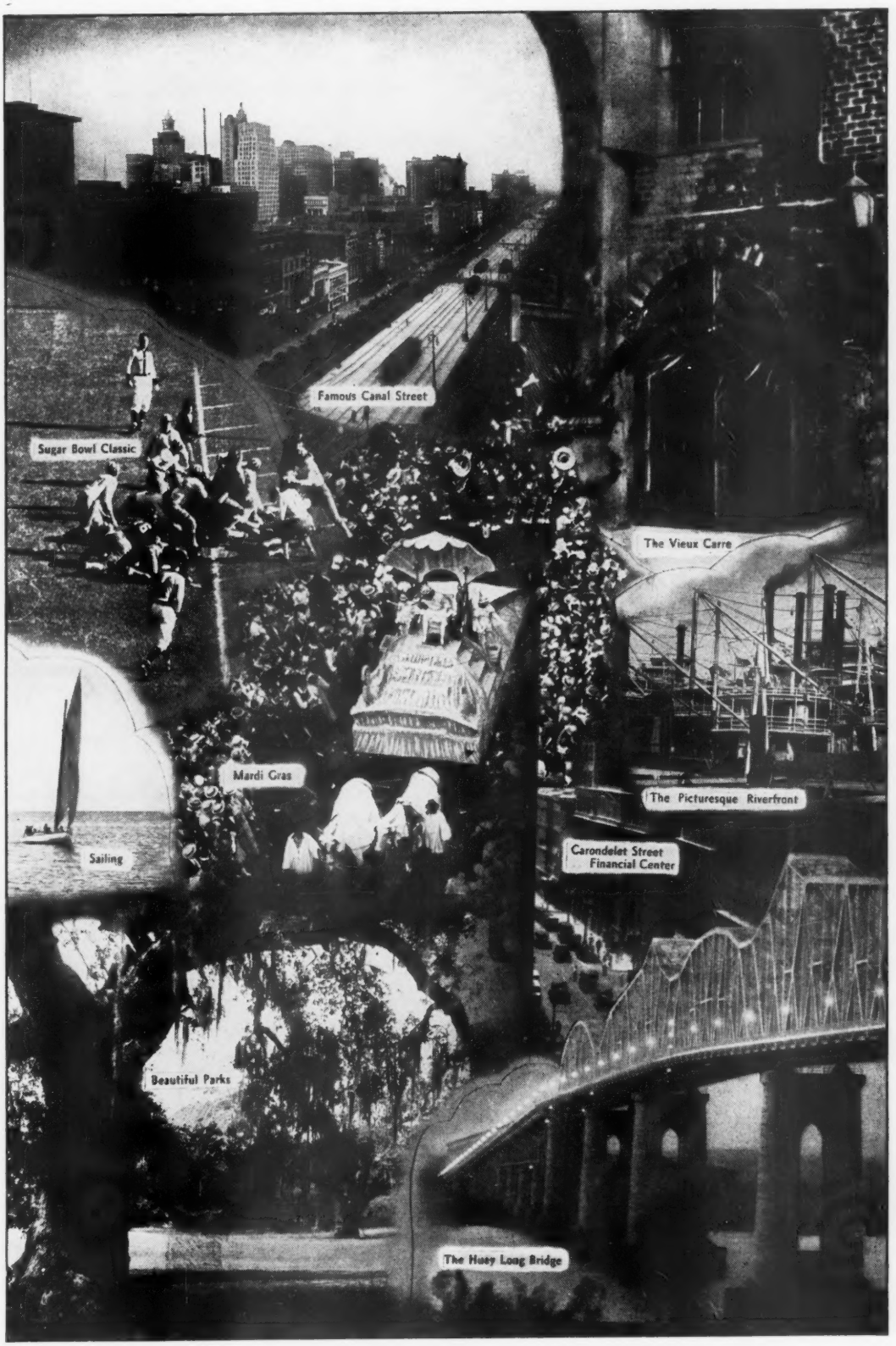
CANNELTON SEWER PIPE COMPANY
CANNELTON, INDIANA

[1] Special report, No. 80, Mellon Institute of Industrial Research for the Eastern Clay Products Association Industrial Fellowship No. 6-A and the Clay Products Association Industrial Fellowship No. 9-B.

All You Can Do by and through This Society, You Do for

Yourself and Fellow Ceramists

OFF TO LOUISIANA IN MARCH, 1938



ACTIVITIES OF THE SOCIETY

A.S.T.M. COMMITTEE ON GLASS ORGANIZED

Standard Tests to be Developed

Previous announcements have been made concerning the suggestions of the Glass Division of the American Ceramic Society that A.S.T.M. organize a new standing committee on glass and glass products. It was pointed out that this committee had been authorized by the Executive Committee and that a preliminary conference on the subject was held in Pittsburgh early in January.[1] The new standing committee, C-14 on Glass and Glass Products, was formally organized at a meeting held during the Fortieth Annual Meeting, New York City, and will provide, in accordance with long-established procedure, an opportunity of bringing together producers, consumers, and general interest groups for the purpose of developing American standards for the testing of glass and glass products.

The temporary chairman and secretary of the committee, G. W. Morey, Geophysical Laboratory, Carnegie Institution of Washington, Washington, D. C., and Louis Navias, General Electric Co., Schenectady, N. Y., respectively, had charge of the meeting. The Steering Committee, which worked with these men in making plans for the organization and initiation of the Committee's work, included representatives of major organizations concerned with glass.

Scope and Personnel of Committee

The scope which was recommended for the Committee was approved. This is as follows:

Scope: The development of nomenclature and methods for analysis and testing of glass, both as such and as specific products.

The Committee decided that the executive direction of the work would be in the charge of three officers and an advisory committee which would include, in addition to the officers, four other members. The election of officers resulted in the selection of Doctor Morey as chairman, Dr. Navias as secretary, and F. C. Flint as vice-chairman. Members of the Advisory Committee who were elected are J. C. Hostetter, J. T. Littleton, A. N. Finn, and G. M. Rapp.

The personnel of the Committee is made up of prominent technologists in the industry, representing producers and consumers and, in addition, a number of general interests. A list of the personnel of Committee C-14 at this time follows:

American Ceramic Society, Inc., J. C. Hostetter
American Pharmaceutical Assn., E. F. Kelly
The Austin Co., Albert S. Low
Bell Telephone Laboratories, Inc., K. G. Coutlee
Corning Glass Works, H. H. Blau, J. T. Littleton, W. C. Taylor
Purdue University, R. B. Crepps
Electrical Testing Laboratories, W. F. Little
National Bureau of Standards, A. N. Finn
Hazel-Atlas Glass Co., F. C. Flint
General Electric Co., Louis Navias
General Motors Corp., H. R. Wolf
Kimble Glass Co., J. F. Greene
Hartford-Empire Co., D. E. Sharp, H. A. Wadman
Chrysler Corp., C. E. Heussner
International Association of Milk Dealers, R. E. Little
National Bureau of Standards, G. E. F. Lundell
Maryland Glass Corp., W. R. Lester
Geophysical Laboratory, Carnegie Institution of Washington, G. W. Morey
New York State College of Ceramics, S. R. Scholes
Owens-Illinois Glass Co., U. E. Bowes, J. H. Waggoner
Pittsburgh Plate Glass Co., J. S. Gregorius
Pittsburgh Testing Laboratory, M. L. Carr
Port of New York Authority, G. M. Rapp
Pittsburgh Corning Corp., J. P. Staples
Mellon Institute of Industrial Research, E. W. Tillotson
U. S. War Dept., O. K. Kaspereit, C. W. Kendall
Libbey-Owens-Ford Glass Co., R. W. Wampler
Westinghouse Electric and Manufacturing Co., C. F. Hill, H. K. Richardson
Whitall Tatum Co., J. L. Bacon, G. E. Barton

After considering various problems which it was felt the Committee should attack, it was decided to appoint six subcommittees. These groups and the respective chairmen are as follows:

I. Nomenclature and Definitions—G. W. Morey
II. Chemical Analysis—G. E. F. Lundell
III. Chemical Properties—D. E. Sharp
IV. Physical and Mechanical Properties—J. T. Littleton
V. Thermal Properties—E. W. Tillotson
VI. Glass Construction Block and Tile—J. P. Staples

In connection with the organization of this Committee, members will recall that at a meeting sponsored by the Pittsburgh District Committee in February, three papers[2] were presented on recent developments in the glass industry, laminated glass and glass fibers. In the paper on "Recent Advances in the Glass Industry," some of the progress made in a general way and in special fields was outlined, the influence of chemistry and physics was discussed and new uses and types of glass were described, including tempered glass, spun glass, glass building block and tile, the sealing of glass to metal, and the fabrication of large masses of glass.

[1] See "Conference on Formation of A.S.T.M. Committee on Glass," *Bull. Amer. Ceram. Soc.*, **16** [2] 71–72 (1937).

[2] These papers were printed in the March BULLETIN of A.S.T.M.

CALIFORNIA SECTION

At a dinner meeting held August 6, 1937, C. A. Miketta, patent lawyer, gave the California Section a most interesting and valuable discussion under the subject, "Patents, Plain and Fancied." Mr. Miketta has had many years of experience in the field of ceramic patents, and has been a member of the American Ceramic Society since 1924.

The meeting was attended by about fifty members.

—TOM CURTIS, *Vice Chairman and Corresponding Secretary*

In Eight Months of 1937
One Hundred and Eighty-Two Personals
and
Nineteen Corporations
are
Added to Passenger List of "Good Ship Ceramics"
Each with First Class Passage Paid

1937 MEMBERSHIP RECORD

Date of Record	Members Paid		Deferred	Subscriptions	Monthly Sales	Total Circulation
	Personal	Corporation				
December 20, 1936	1452	196				
January 20, 1937	1478	199				
February 23, 1937	1579	210	19	515	220	2543
March 29, 1937	1613	212	18	524	220	2587
April 23, 1937	1517	209	29	485	220	2460
May 22, 1937	1541	209	25	501	220	2496
June 22, 1937	1572	211	23	502	220	2528
July 20, 1937	1607	212	20	506	220	2565
August 23, 1937	1634	215	17	509	220	2595

In the hot vacation month of August there were 27 Personal and 3 Corporation Members added to our sailing list. During the cool months, with everybody pointing toward the big Fortieth Annual Meeting in New Orleans the week of March 27, there should be a record assemblage on board. It is up to you, you, and you, individually and personally.

Is it right and becoming to invite acquaintances to participate in this sailing on Ceramic Progress River? If you think so, do it.

Memberships are for the calendar year. Those joining in September may, if they so elect, pay only the aliquot portion of the yearly dues, i.e., one-third.

Corporations, having for years been beneficiaries of the work of this Society, should feel privileged to pay the entire minimum annual fee of $25.00 for 1937 and accept gladly in December a bill for their 1938 minimum supporting fee of $25.00.

NEW MEMBERS

Corporation

PRECISION GRINDING WHEEL CO., George F. Kohn (voter), 8301 Torresdale Ave., Philadelphia, Pa.

*STERLING GRINDING WHEEL CO., A. E. Tulk (voter), Tiffin, Ohio.

STRUCTURAL CLAY PRODUCTS, INC., Harry C. Plummer (voter), 1427 Eye Street, N. W., Washington, D. C.

Personal

BOWMAN, JOHN G., University of Pittsburgh, Pittsburgh, Pa.; educational administrator.

BOZMAN, W. D., Denver Pressed Brick Co., Loveland Plant, Loveland, Colo.; manager.

HENNESSY, WILLIAM J., 1 N. LaSalle St., Chicago, Ill.; convention manager, Chicago Assn. of Commerce.

LANGLEY, RAYMOND M., 610 Clark Building, Pittsburgh, Pa.; sales engineer, Johns-Manville Corp.

PHILLIPS, EDWIN L., H. C. Spinks Clay Co., 502 Monmouth St., Newport, Ky.

SPENCE, HAROLD I., 2516 Twin Oak Street, Los Angeles, Calif.; ceramist, General Tile Corp., El Segundo, Calif.

SWINNERTON, BERTRAM B., 21 2nd Ave., Tiffin, Ohio; manager, Standard Sanitary Mfg. Co.

TRAINOR, LEE S., 927 15th Street, N.W., Washington, D. C.; chief engineer, National Lime Association.

WEBSTER, MRS. ANN, 634 Garcia Road, Santa Fé, New Mexico.

WHITAKER, LORENZO R., Box 291, New Brookland, S. C.; ceramic engineer, Guignard Brick Works.

Student

FRANCISCO, ALLEN C., N. Y. State College of Ceramics.

WILSON, JAMES E., Jr., N. Y. State College of Ceramics.

ROSTER CHANGES DURING AUGUST

Personal

BELL, FRED S., P. O. Box 242, Gleason, Tenn. (St. Louis, Mo.).

BOWES, URBAN E., 315 E. Front St., Perrysburg, Ohio (Toledo, Ohio)

CLARK, EMORY W., Georgia Kaolin Co., Dry Branch, Ga. (Atlanta, Ga.)

ECHAVARRIA, NORMAN, c/o S. J. Bris Bin, 17 Rector St., New York, N. Y. (Alfred, N. Y.)

FROST, LEON J., Box 138, Lewiston, N. Y. (Niagara Falls, N. Y.)

GLEAVES, WILLIAM H., Montgomeryville, Pa. (Lansdale, Pa.)

GRIFFITH, RULON L., Box 64, Claysburg, Pa. (Reading, Pa.)

GROUT, JOHN R., JR., Canada China Clay Co., St. Remi d'Amherst, Quebec, Canada. (Spruce Pine, N. C.)

HAFF, ROBERT S., JR., Box 331, Blacksburg, Virginia. (West Frankfort, Ill.)

HATCH, EDWIN F., 333 Washington Ave., Clarksburg, W. Va. (New Brunswick, N. J.)

HURST, THOMAS L., 140 Vreeland Ave., Leonia, N. J. (Seattle, Wash.)

ILGENFRITZ, C. BRUCE, 533 S. Duke St., York, Pa. (Pittsburgh, Pa.)

KEY, JOSEPH B., R. R. 2, Kansas City, Kans. (Manhatten, Kans.)

KIRKPATRICK, F. A., Pomona Tile Mfg. Co., Pomona, Calif. (Morton, Ill.)

MASSEY, CRAWFORD, 1334 N. Lakewood Ave., Downey Calif. (Los Angeles, Calif.)

MINTON, G. Z., Pittsburgh Plate Glass Research Lab., Creighton, Pa. (Crystal City, Mo.)

MURPHY, REMINGTON M., Architectural Tiling Co., Keyport, N. J. (Elmira, N. Y.)

NICHOLSON, CLIFFORD M., c/o Canadian Nepheline Ltd., Box 525, Lakefield, Ont., Canada. (Regina, Sask., Canada)

PORTER, ALLEN K., Melting Dept., Corning Glass Works, Corning, N. Y. (Champaign, Ill.)

QUIRK, JOHN F., 812 E. Second St., Flint, Mich. (Columbus, Ohio)

RALSTON, OLIVER C., Nonmetals Division, U. S. Bureau of Mines, College Park, Md. (New Brunswick, N. J.)

REIF, RICHARD E., 1707 Cedar Rd., Homewood, Ill. (Elmhurst, Ill.)

ROBINSON, G. R., 594 Warner Ave., Logan, Ohio. (Columbus, Ohio)

SPENCER-STRONG, G. H., 403 E. Washington St., Sandusky, Ohio. (Baltimore, Md.)

STAFFORD, W. L., Johns-Manville Research Lab., Manville, N. J. (East Liverpool, Ohio)

TAUBER, JOHN A., 1035 DeKalb St., Norristown, Pa. (Columbus, Ohio)

THORLEY, JOSEPH P., 6321 Tree Chept Rd., Richmond, Va. (East Liverpool, Ohio)

WHITE, MILO A., JR., 2429 S. Salina St., Syracuse, N. Y. (Pittsburgh, Pa.)

Student

FRÉCHETTE, VAN DERCK, 191 McLeod St., Ottawa, Ont., Canada. (N. Y. State College of Ceramics)

SKINNER, ROBERT, Attica, N. Y. (N. Y. State College of Ceramics)

*Indicates former member of the Society rejoining for 1937.

Membership Workers' Record

Corporation

Office	3

Personal

R. B. Carothers	1	E. W. Tillotson	1
R. F. Rea	1	Walter Weldon	1
R. B. Sosman	5	A. F. Greaves-Walker	1

Student

Robert Campbell	1	R. B. Sosman	1
		Grand Total	15

Forward-going aggressive persons succeed only by continually studying, not narrowly, but broadly the current problems in all ceramic fields.

PRESIDENT'S MESSAGE

CONSTITUTIONS

I quote from a History of the World, written in the year 2237 A.D.:

"America's principal contribution to Twentieth Century civilization was not the radio nor mass-production, profound as were the effects of these inventions upon politics and economics. It was, rather, a spontaneous and ultimately healthful disrespect for the meticulous laws that legal gentlemen in legislatures had become accustomed to enact in vast numbers for the control of others. We should say in their defense that, almost totally lacking the fundamental facts of psychology, psychics, and psychodemography essential to such enactments, they were in the same uncomfortable position as the medieval physician, ignorant of chemistry, biology, and anatomy, but under the desperate necessity of acting, not theorizing. Not until the psychological discoveries of the Twenty-First Century had revolutionized our concepts of the natural behavior of human beings when under restraint, could public laws be set up whose workability was predictable and which thereby became entitled to the label 'scientific.'"

Being still in the benighted state described by the historian, we of the American Ceramic Society in the year 1937 find ourselves, just as he stated, under the necessity of acting in a legal environment that is almost completely empirical. The Society is an incorporated non-profit-making body under the laws of the State of Ohio. The group of people that forms the Society is required to govern its affairs through some kind of Board of directors or trustees, selected in a way that deprives no member of a voice in the management. The titles and duties of officers are expected to be defined, and the classification and grading of members with respect to their privileges and responsibilities should be clearly stated. Finally, General Code 8623 provides that there must be some arrangement by which the members may amend the *Constitution* in which the above-mentioned provisions are embodied.

The simpler and briefer this Constitution can be made, the better. Under Keith McAfee's direction, and with the invaluable advice of David McKinley, we believe we now have a Constitution that will not need much further amendment unless the character and purposes of the Society should change radically, but we must recognize that it is an experiment, and not unalterably final.

We shall assume that the average member of our Society thus has his personal interest in it protected by a Constitution that is neither too vague nor too detailed, and that is furthermore self-limited in its manner of amendment so that no small minority can run away with it before the majority wakes up. It is fairly certain that he will be perfectly satisfied to let the Board of Trustees specify the particulars. These include assessing the dues or other contributions, describing the manner in which nominations and elections shall be conducted, defining the duties of standing and special committees, and the like. This body of regulations constitutes the *By-Laws*, drawn up and adopted by the Board and made known to the membership, but not referred to the membership for ratification unless such reference is demanded and the demand is incorporated in the Constitution. The By-Laws can be amended by the Board, but only after due notice to all its members, again guarding against hasty action by a minority. Such By-Laws have now been adopted and published.

Finally, the separate classifications of the membership—in the Ceramic Society these include the Fellows, the Classes (Institute of Ceramic Engineers), the Divisions (Glass, Enamel, etc.), and the Local Sections—must have regulations for their own guidance that need not be uniform, but must not be in conflict with the Constitution and By-Laws. These regulations are the *Rules*, which are now being revised under the watchful eye of McAfee's Committee.

If the time ever comes when nobody in the Society wants to amend the Constitution, By-Laws, or Rules, we will know that the Society is dead, but there are no signs that we are anywhere near that stage of our history. I thought of several improvements myself while the By-Laws were in press.

—ROBERT B. SOSMAN

WHY A CORPORATION MEMBERSHIP

This Society was organized in 1898, incorporated in 1899, and for twenty years was a very active academic institution promoting ceramic research. During those twenty years it actively campaigned for the establishment of the Bureau of Mines, it gave support to Dr. Stratton when he was organizing the Bureau of Standards, and promoted ceramic education and research in the several federal and state geological surveys and universities.

During the first twenty years the Society functioned very well as an academic institution, supplementing the universities, the bureaus, and the several research institutes.

In 1918 the Society was reorganized, established Industrial Divisions, Local Sections, Student Branches, etc., and made the transition from Annual Transactions to a monthly *Journal*. During this second twenty years of its activities this Society developed the compilation and publication of abstracts of world-wide literature of interest to ceramists, published a monthly *Journal* of ceramic research, and a monthly publication, known as *The Bulletin*, which is devoted to the promotion of industrial ceramics and of ceramic education and research.

The members receive three publications monthly, each with its own pagination, and in December each has its own Index.

During this second twenty years of the existence of this Society, the scope and direction of its activities have changed with the changing requirements, especially as reflected in the ceramic industries. The several officers and committees have given of their time, energy, and talents without compensation. All resources from the publications are devoted to the prosecution of the work of the Society in the interest of the ceramic industries.

The expense of all of these activities is far greater than the individual members can afford to pay, even though Personal annual dues are $12.50. For this reason the officers and members of the Society are asking the ceramic industries to help finance this work through Corporation Memberships, with a minimum annual payment of $25.00.

In Germany, England, and other countries, these Corporation Memberships range from $200 up. It seems quite picayune to ask the American ceramic industries to support this work by the payment of at least $25.00, and yet this is sufficient if a goodly number of corporations contribute.

In the July issue of *The Bulletin* will be found a list of Corporation Members that are now supporting the Society.

PRONUNCIATION OF CERAMIC—"SERAMIC" OR "KERAMIC"?*

Editor of the Sentinel: Mr. Fred Rhead, in his lecture to the Society of Industrial Artists last night, pronounced that word familiar to all of us in the Potteries as "Seramic."

As it is derived from the Greek word "Keramos," is not the correct pronunciation "Keramic," or are both correct, or both used universally?

I shall be glad of a ruling on this point.—*Anglo-American*

New Union's Reply to Trades Council

The question of the pronunciation of "ceramic" is not one for the potter or language expert to decide. The arbiter in these matters is the man-in-the-street. What he finally accepts is the standard.

The French "garahzh" is fast becoming "garrage" (pronounced like "passage") and "vitamin" was originally "vitamine," with various pronunciations.

As regards "ceramic," we have introduced into English a number of Greek words with the initial letter "k," changing this into "c." Now "c" before "e" or "i" is *sibilant*, that is, since the time of the French William the Conqueror. Hence "seramic."

In Anglo-Saxon times, the word would have been pronounced "keramic." Since the Conqueror, the hard sound of "c" before "e" and "i" is denoted by" k", *e.g.*, "cyn" is now "kin" and "cyng" is now "king."

—*T. Murphy*

* From the *Evening Sentinel*, Stoke-on-Trent, June 9 and 14, 1937.

NECROLOGY

GERMAN CERAMIST DIES

It is with regret that we learn of the death of Wilhelm Pukall, of Bunzlau, Germany, at the age of seventy-eight. He died on July 13, 1937, at noon.

Dr. Pukall spent a long and active life devoted to ceramic plant practice, research, and education, and gained for himself an international reputation. Dr. Pukall was Trade School Director Emeritus and Trade School Counselor.

Coming from the Royal Porcelain Works in Berlin, in 1897 he became the first Director of the Royal School of Ceramics in Bunzlau, and was the active head of this institution for many years.

In 1904 he visited this country and acted as one of the judges of ceramic products at the St. Louis World's Fair. This gave him an opportunity to visit a number of plants and make many new friends, and was one of the most treasured experiences of his life.

About twelve years ago he retired from active service and devoted his time to research in a laboratory placed at his disposal by the Hoffmann sewer pipe plant in Bunzlau, Germany, where the writer had the pleasure of visiting him in 1927 and again last year.

He was the author of numerous articles, and one of his achievements was the rehabilitation of the old Bunzlau pottery industry to a high stage of development by the introduction of modern practice.

His former students, located all over the world, and his many friends, sorrow at the passing of this "grand old man" and extend their sympathy to his family.

Wilhelm Pukall

He is survived by his wife, a son, and two daughters.

—F. A. Whitaker

OLIVER W. RENKERT

Oliver W. Renkert, a leading figure in the clay products industry, died at Lake Nipissing, Ontario, Canada, August 6, 1937, at the age of fifty-nine. Mr. Renkert was born in Dover, Ohio, and was educated in dentistry, being a graduate of the Western Reserve Dental School. After practicing for several years he joined the organization of the Metropolitan Paving Brick Co. and was in charge of the plant at Moberley, Mo., until 1913 when he was transferred to the main office at Canton, Ohio.

In 1922, upon the death of his brother, Harry S. Renkert, he succeeded him as president of the Metropolitan Paving Brick Co., which is the largest manufacturer of paving brick in the industry, having plants and subsidiary companies in Ohio, Pennsylvania, and New York. In addition to paving brick, this Company is also an important factor in the production of building brick and tile.

Oliver W. Renkert became a member of The American Ceramic Society in 1922. Since that time he served on many committees.

Mr. Renkert has always been an active and directing figure in the paving brick and structural clay products industries as was manifested by his zealous support of trade associations in that field. He had served as president of the National Paving Brick Assn. since April, 1931, and when the Structural Clay Products Institute, which represents all branches of the heavy clay products industry, was formed in 1935, he was made its first president, and was on his second term in this office at the time of his death.

Although Mr. Renkert had been in failing health for several months, his death at this time was unexpected. He was on a vacation, engaged in his favorite pastime of fishing, with his wife and other members of his family. Funeral services were held in Canton, Ohio, August 9, 1937.

Oliver W. Renkert

SAMUEL B. BOWMAN

Samuel B. Bowman, leading industrialist of Zanesville and factories manager of the Hazel-Atlas Glass Co., died July 30 at Johns Hopkins Hospital in Baltimore, Md., from complications that developed following an operation undergone July 22. Mr. Bowman was fifty-three years of age.

Samuel B. Bowman

Although his death followed an illness of several months, the seriousness of his case was not realized until recently. He was first stricken in April when he was returning from a business trip in the west. Shortly after being admitted to Johns Hopkins Hospital, an operation was deemed necessary. From that time until his death it was realized that Mr. Bowman would not recover.

Native of New York

Samuel Benjamin Bowman was born in Allentown, N. Y., May 20, 1884. In 1889, he moved to Washington, Pa., where in later years he was graduated from the Washington High School after which he attended Washington and Jefferson College.

Mr. Bowman went to work for the Hazel-Atlas Glass Co. in 1906 at the Atlas plant in Washington, Pa. In the following years, he served the Company in various capacities at Blackwell, Okla., Clarksburg and Grafton, W. Va., Omaha, Neb., and Wheeling, W. Va.

In 1924, Mr. Bowman was made district manager of the Ohio-Oklahoma district with factories in Blackwell, Okla., and Zanesville, at which time he made his home in Zanesville.

Under his management, the district expanded to include factories at Ada, Okla., Oakland, Calif., and Lancaster, N. Y.

In February, 1934, Mr. Bowman was made general factories manager of the entire Hazel-Atlas organization, comprising thirteen plants with headquarters in Zanesville.

As manager of these plants, Mr. Bowman was a busy man, yet he found time from his business cares to take an active part in the work of his church in which he was a leader, and his religion was not of the Sunday variety, but was practiced every day in the week. He was a generous but unostentatious contributor to all charities, believing it a duty and a pleasure to share his substance with his less fortunate fellows.

Samuel B. Bowman was a loyal friend and good neighbor, whose passing will be sincerely mourned by all who knew him.

TWO MORE FILMS FOR VISUAL PROMOTION OF CERAMICS

There are two more films available for visual promotion of ceramics, each of which makes a splendid addition to the list published in the May, 1937, *Bulletin*. "The Evolution of Mullite Refractories" (35 minutes, silent) depicts the story of mullite in its application to refractories, and offers a number of graphic examples showing the influence of the percentage of mullite in a bonded refractory body. The second film, "An Inside Story of Ceramics" (35 minutes, silent) deals, in general, with the effect of stable aggregate in porcelain bodies and draws comparisons between such stable aggregate and the usual quartz.

The above films may be borrowed by the payment of transportation charges (both ways) from Frederick Sammons, Vitrefrax Corp., 5050 Pacific Boulevard, Vernon, Calif.

C. ROBERTSON ON COLOR COUNCIL

On account of transfer to another department of work, J. H. Young of E. I. du Pont de Nemours & Co. has resigned as one of the Society's representatives on the Inter-Society Color Council. C. Robertson of the R. & H. Chemicals Department of the du Pont Company has accepted the appointment as his successor.

AMERICAN CERAMIC SOCIETY NEW ORLEANS, MARCH 27–APRIL 2, 1938

Going and returning direct, Cincinnati to New Orleans and return, one can use the following schedules on the L. and N. Railroad:

Lv. Cincinnati	10:00 A.M.	7:15 P.M. (EST)
Ar. New Orleans	7:55 A.M.	7:40 P.M. (CST)
Lv. New Orleans	8:45 A.M.	8:20 P.M. (CST)
Ar. Cincinnati	11:55 A.M.	9:20 P.M. (EST)

On the going trip one can stop over at Decatur, Ala., and make a side trip to Muscle Shoals, leaving Cincinnati at 7:15 P.M., arriving Decatur at 5:21 A.M., leaving Decatur 7:17 P.M., arriving New Orleans 7:55 A.M. Returning, leave New Orleans 6:30 P.M., arriving Knoxville 12:49 P.M., leave Knoxville at 9:00 P.M. or 11:12 P.M., arriving Cincinnati 7:40 A.M. or 8:10 A.M.

For the side trip Decatur to Muscle Shoals, there will be a charge of $1.40 per person for the round trip and it will consume one hour in each direction to make the trip.

On the return trip, in connection with the side trip from Knoxville to Norris Dam, the round-trip rate will be $1.00 per person, the time consumed being one hour in each direction. Under the present arrangement, the TVA people at Norris show parties through the Power House and also give a very interesting lecture. This lecture consumes a little more than two hours.

The round-trip rate, good fifteen days from Cincinnati to New Orleans, is $33.75, either direct or returning via Knoxville. Lower berth rate one way is $6.00, drawing room, $21.00, compartment, $17.00.

JOHN H. GENTRY
TRAVELING PASSENGER AGENT
LOUISVILLE and NASHVILLE RAILROAD
407 GWYNNE BLDG., CINCINNATI, OHIO

PACIFIC-NORTHWEST SECTION

The summer meeting of the Pacific-Northwest Section was held Saturday, August 28, 1937, at the St. Helen's Hotel, Chehalis, Wash.

An interesting and informal program was prepared by the executive committee, the members of which are Neal Fosseen, *President*, Fremont Burrows, *Vice-President*, and Hewitt Wilson, *Secretary*. The following subjects were included in the program: (1) Recent developments in the manufacture of refractories, (2) Vacuum treatment of Chehalis clays, (3) Clays of southwestern Washington, and (4) Labor and general plant problems.

The southwestern Washington group prepared excellent entertainment for Saturday evening and Sunday morning.

—HEWITT WILSON, *Secretary*

Membership in American Ceramic Society

FOR CONTINUING EDUCATION IN CERAMICS

SCHEDULED AUTUMN MEETINGS

CERAMIC ASSOCIATION OF NEW JERSEY AND THE MATERIALS AND EQUIPMENT AND WHITE WARES DIVISIONS, AMERICAN CERAMIC SOCIETY
Pocono Manor Inn, Monroe County, Pa., September 16 and 17.

AMERICAN REFRACTORIES INSTITUTE
Colorado Springs, Colo., Broadmoor Hotel, October 1.

CERAMIC ASSOCIATION OF NEW YORK
Alfred, N. Y., October 8 and 9.

PITTSBURGH SECTION, AMERICAN CERAMIC SOCIETY
Pittsburgh, Pa., Mellon Institute, 4400 Fifth Ave., October 12.
SPEAKER: N. W. Taylor, Pennsylvania State College.
SUBJECT: "Some Technical Problems in the Beneficiation of Clays."

PORCELAIN ENAMEL INSTITUTE
Chicago, Ill., October 11 and 12.

PORCELAIN ENAMEL INSTITUTE FORUM
Columbus, Ohio, Ohio State University, October 13, 14, and 15.

ART DIVISION, AMERICAN CERAMIC SOCIETY
Syracuse, N. Y., October 28, 29, and 30 (see page 344, August *Bulletin*, for preliminary program announcement).

OHIO CERAMIC INDUSTRIES ASSOCIATION, ANNUAL MEETING
Columbus, Ohio, Ohio State University, November 5 and 6.

PORCELAIN ENAMEL INSTITUTE SEVENTH ANNUAL MEETING

The Seventh Annual Meeting of the Porcelain Enamel Institute will be held in Chicago on October 11 and 12. A comprehensive program is being developed. Election of 1938 directors, members of the Executive Committee, and officers, will be held at the meeting and a complete Institute and Educational Bureau program for 1938 will be submitted for approval.

Porcelain Enamel Institute Forum

The Second Porcelain Enamel Institute Forum will be held at the Ohio State University in Columbus, Ohio, October 13, 14, and 15. The following members of the Forum Committee have arranged a suggested program: F. E. Hodek, Jr., General Porcelain Enameling & Mfg. Co., 4101 Parker Ave., Chicago, Ill., *Chairman;* A. I. Andrews, University of Illinois, Urbana, Ill.; R. M. King, Ohio State University, Columbus, Ohio; and J. E. Hansen, Ferro Enamel Corp., 4150 E. 56th St., Cleveland, Ohio.

NEW ORLEANS IS IDEAL FOR 40th ANNUAL MEETING

March 27–April 2, 1938

Statement by Ellsworth Woodward, former Dean of the Art School at Newcomb College, New Orleans, and now President of the Isaac Delgado Museum of Art.

"It is my conviction that the necessary papers, expert speeches, and all the desirable circumstances of a successful meeting of experts could be secured and presented anywhere; but in addition to, and beyond, practical contacts with successful manufactories and laboratories are definite though intangible factors in life and human relationships that can not be encountered by stay-at-homes whose minds can not be detached from their daily preoccupations.

"I am sure that New Orleans has something that will challenge the admiration of practical men even in the field of their special interest; but to the mind gaged at a wider angle, the question as to why the deep South is deficient in this and that will sting its way into consciousness and widen the sense of belonging to one great nation—the greatest potentially on earth, if only we can be brought to realize that only in union is there strength. What I am trying to say is that it is salutory for busy, important men occasionally to be persuaded out of their narrow routine to see how other men, who are their equals in every way, look at life which has been shaped by different conditions and environment.

"In a word, I think that delegates to the Ceramic Meeting in New Orleans should come for the enlargement of their American souls. Such increase is never to the disadvantage of business."

ELLSWORTH WOODWARD, *a Transplanted Yankee*

From letter by Franz Blom, Tulane University, Louisiana, Department of Middle American Research, New Orleans, to Mrs. Martha Westfeldt, dated August 7, 1937.

"I was glad to have your letter and wish to assure you that we will be delighted to put up a really good show at the Meeting of the American Ceramic Society, in New Orleans in March. I judge that they will have their meetings in the auditorium and would appreciate it if you could arrange a good space for us for an exhibit. You know that we are not able to pay for the space but I can assure you that we will make a fine exhibit of pre-conquest ceramics. I would want to include the full-sized figure by Alferez, dressed in native Guatemala costume and shown making a pot. At the same time we would show modeled and mold-made figurines if you think that would be of historic value."

CELO KYANITE
UNIFORM QUALITY DEPENDABLE SUPPLY
FOR INFORMATION AND SAMPLES WRITE TO
CELO MINES, INCORPORATED
BURNSVILLE, NORTH CAROLINA

WHY OUR MEMBERS ENTHUSE FOR ANNUAL MEETING IN NEW ORLEANS

March 27–April 2, 1938

Most of us have not been fortunate enough to be put into a position where we can see general trends in place of just individual motions.

We on the Board voted that the Ceramic Society should go to New Orleans because, over the years, as we had looked at the various cities and sections of the country, we felt that New Orleans and the South represented a potential consumers' market which has been thought little of by most of us, except from a political angle. The education of the consuming public is one of the very natural functions of the Society.

Different sections of the country must be served. Those who live in the West will find that it costs no more to go to New Orleans than to New York, and when there it will undoubtedly cost much less. We have a habit of thinking in terms of East and West easier than North and South, even though the distances are not as great.

FRANCIS C. FLINT, *Past-President*

In reference to the Meeting at New Orleans, I can only say that I am very enthusiastic about it as neither Mrs. Child nor myself has ever been there.

After checking the attendance records of other societies, I feel that we will have a very good representation because many people will make it a combination pleasure and business trip. As a matter of fact, it is just as easy for the entire Middle West to go to New Orleans as it is to go to New York.

All the comments which I have heard in this section are very favorable to New Orleans.

J. LEO CHILD, *Trustee from Structural Clay Products Division*

The more I think of New Orleans, the more I feel that it will be an ideal Meeting place for the American Ceramic Society. There is only one drawback—that is the question of time to make the trip, but that item is more than offset by the advantages offered.

In the first place, to the average member, the railroad fare and the hotel expenses will be considerably less than if the Meeting were held in some of the northern cities.

Many of our members have a deep personal desire to see the beauties of this historic city (I don't want anyone to misconstrue the word "beauties").

The Society owes something to the Student Members in the southern universities, and they will be more than glad to go to New Orleans. Furthermore, there are great developments in ceramics going forward in the South, and our Meeting in New Orleans will make the South even more ceramic conscious.

The southern markets have been sadly neglected by the ceramic manufacturers, and many of our members would be amazed at the vast tonnage of English and Japanese ceramic ware used in that territory. Isn't it logical to believe that our Meeting in New Orleans could be made a force for converting many Southerners to American-made ware?

Aside from the commercial advantages, and undoubtedly an excellent technical program, our members will have an opportunity of meeting new, enterprising people who have a determination to make the South go forward industrially.

I feel sure the Refractories Division will attend in large numbers. They never have "let down" the Society, and they never will.

CECIL E. BALES, *Trustee from Refractories Division*

Upon my return from Europe I find plans for the next Meeting well under way, with New Orleans as the Meeting place.

It seems to me that the Society does well to hold its Meetings occasionally in comparatively new fields, although somewhat "off the beaten track." Being national in scope and membership, we should not completely forget the members and broad ceramic interests in districts in which there may not be as many ceramic industrial enterprises as in the East and Middle West.

As far as our Art Division is concerned, I am pleased at the prospects of a New Orleans visit, as I believe the development of individual potters and pottery has been particularly active at New Orleans and along the Gulf Coast. We of the Art Division have never sought a meeting place because of our divisional preferences, but are pleased when there are unusual attractions for us at the selected places. We believe the midyear meetings, such as those we have held at Syracuse and Baltimore, will take care of our special field and its exploitation.

L. E. BARRINGER, *Trustee from Art Division*

In the past, I have stayed away from Meetings in Toronto, Atlantic City, and Atlanta, because they were either far away (expensive) or were out of the ceramic districts. The reactions of those attending such Meetings, however, were always so fine that I felt that I had missed something. Consequently, this time, I felt that there was another grand Meeting in the making and I wanted to be there (I pay my own expenses), so I cast my vote for New Orleans.

Another reason for voting to go to New Orleans was to back up a commitment that the Society had made every year for some years back, *i.e.*, to go to New Orleans when times were better. And now seems to be the time!

There is the question as to whether it is best to confine our Meetings to the Mid West and East or to branch out in various directions. This is a good time to obtain a definite reaction from the Society members, which will definitely mold the policies of the Society as to Annual Meeting places for some time to come.

JOHN L. CARRUTHERS, *Trustee from Terra Cotta Division*

With reference to correspondence regarding the recent meeting of the American Ceramic Society in New Orleans, perhaps I am not a very good one to state the reasons why any individual member should attend this meeting as I see no reasons whatever why they should stay away. However, I am submitting the following statement as the reasons which appear to me in particular:

Of course, having lived in New Orleans for two years and having received a degree from Tulane University of Louisiana, I have some particular personal reasons for desiring to return to New Orleans. However, since there are many other places where I have been and stayed just one day to which that I have no particular desire to return, it is apparent that my two years in New Orleans were pleasant ones.

I believe that the first and main consideration for a meeting place are the convention facilities of the city. Will we have desirable Meeting rooms? Will we be able to get a fair amount of rest following the Meetings and will the locality be such that individual groups can get together in the slack moments? This is a matter for the local committee to arrange and can be no doubt taken care of at almost any locality or city of sufficient size.

New Orleans in particular will take care of the above details for us. I am aware that the rooms in the hotels are considerably larger than the rooms in the usual Northern hotels. We can be assured that we will be better taken care of so far as personal comforts are concerned than we ever have been before.

Beyond the affairs of the Meeting itself we must consider the educational value of the location. There is no city in the U. S. which compares to New Orleans in its uniqueness. It is very much like a foreign city in many respects and is one which every American should at some time visit.

Again, there is another side to think of in visiting a strange city and a strange locality and a people whose business and customs are somewhat different from those with which we are acquainted. Most of us care very little about visiting factories in our own line of manufacture at Meeting times. If we think it desirable to visit such an institution we usually arrange to do that at some other time and unquestionably such visits are much more profitable than attendance with a group. I would much prefer to visit such places as silk mills, cotton mills, sugar refineries, and even large lumber yards to visiting a glass plant. I believe that our ideas will be more stimulated by seeing the manufacture of something entirely different from our own particular line. I might call to mind that certain glass-working machines are very similar to candy-making machines. I believe that, if we could see our way clear to have an exhibit in New Orleans, such an exhibit would attract many local people and be of more interest than it would be in any other city in the U. S. We should recall in this connection the importance of New Orleans as an entrance market to South America.

I do not estimate that it will cost me more than $25.00 additional to attend a meeting in New Orleans than it would in Detroit or Chicago. I am looking forward to some arrangements being made with the railroads which will facilitate transportation and tend to eliminate the extra lost time in attendance. As a matter of fact, the North and South trains appear as finely equipped as any in the world and I would suggest that each member, before he thinks too much about New Orleans as an inaccessible place, acquaint himself with the railroad facilities. For instance, a train leaving Chicago at noon is in New Orleans the next morning. I have to leave Corning at 4:00 in the afternoon in order to get to Chicago the next morning.

I personally am inclined to think that many of us feel that we ourselves would like to visit New Orleans which, therefore, may be a good reason why we should not. In other words, we strain our conscience backward in order to feel that we are being fair to the company which we represent. I assure you that you need not be so puritanical, for if the Meeting is beneficial to you, it will be beneficial to your company.

J. T. Littleton, *Trustee from Glass Division*

In reply to your letter of August 12 in which you like the "letter because it is written by one who has lived in New Orleans and still wants to go back"—anyone who ever lived in Orleans and *could* go back *would* go back.

J. T. Littleton

SALT OF THE EARTH*

By Raymond Tifft Fuller

When railroads came in, stage-coaches went out: the cinema drove the theater from most cities; with the trolley's advent the horse-car vanished. Business and commercial upsets galore have come and gone; it is the fate of money investments all too often. A new trick here, an invention there, and ultimate results are so far-reaching one can scarcely follow them beyond his own line of bread-winning.

All of which would be inexcusably platitudinous, except that it introduces you to an odd turn of events, an unexpected situation, in one tiny corner of the American scene which I for one would never have thought about had I not been led into a *salt mine*. Who could have guessed how the

Interior Avery Rock Salt Mine; 75-foot arch; near New Iberia, La.

* Reprinted with permission from the author and from *This Week* (*New York Herald-Tribune*), June 27, 1937.

automobile crippled the salt industry, how the dynamo delivered the finishing stroke; and how, later, the automobile revived it?

That salt mine! In America, not in Siberia, Germany, or Poland. Weeks after, I haven't quite recovered from the shocks of it; the several shocks to my intellect and to my senses—and to my emotions, for that matter— which that one hour forced upon them. Being "sentenced to labor in the salt mines" would have absolutely no terrors for me now; it would seem a hermit's retirement rather than a criminal's penalty.

If first you will permit me to take you down 550 feet into solid rock, then perhaps I would be able to explain how recent evolutions in the automotive and electric power age affect the very salt of the earth.

Two of the busiest salt mines in this hemisphere are in Louisiana. One of them is at the very edge of the Gulf itself; the other is farther inland. Two thousand miles from home, I just had to see the inside of one.

"May I go down with the next load of empties?" I asked the Irish superintendent. (I am one who believes in getting to the man highest up.)

"You *may* not—but you *can*," he answered. "It's agin the rules. Get in wid ye!" And he urged me into the lift.

The huge car began to descend.

Two men went down with me. That is to say, they were alongside me when the gates closed above and when they opened five hundred-odd feet below; but I didn't *see* them en route. Nor hear them. If there is blackness on this globe of ours, it is in a mine shaft, for there it is darkness plus stillness and strangeness. (Stillness utterly, if the hoist mechanism is well oiled. Here it was.)

Absolute, pitchy—one wants to say *velvety* blackness, yet the slightly acrid, seashore-like smell I detected did not connote velvet. Sensations told me we were descending slowly. Seconds which could easily have been minutes went by. Then all at once an eery light below — such as steals in through the frosted chamber window at seven of a Christmas morning in the Adirondacks. Heavy, crusted frost seemed everywhere. Glowing first from below, then all around; white, as if we were going deep down into a titanic snowdrift.

The sudden flash of a line of electric lights along a huge corridor! Ah, now this did look like a mine gallery I was facing. But a gallery in a mine the like of which I had never seen nor imagined.

The bowels of the earth should not be *white*—yet every inch of them that I could see was white as alabaster. They sent back a million sparkles. Crystalline — as soft alabaster is not. I stepped from the lift out along the narrow-gage rail tracks and went over to touch the walls. From that moment my human companions ceased to exist for me; I was enchanted into speechlessness by what I beheld, item after item of a unique experience. I stroked the walls wonderingly; they were 98.3% pure salt, NaCl: *rock* salt—hard, jagged, quartz-like, a veritable gold mine of a salt mine!

How warm it was down here! 10 degrees warmer, I learned later, than the world of sunshine I had left above and always at 70 degrees the year around. How dry the air! Underfoot the granulated waste salt on the "floor" would not have been like sand if any humidity had been present in this subterranean atmosphere.

Now I peered down along my strange street, then aloft. Shades of the Primeval Past, what a burrow for a dinosaur! My gaze flickered out beyond a hundred feet in the scantly lighted gloom; overhead I stared as up into the massive marble ceiling of some unearthly nave. Above, white; along the corridor obscure mystery in dimensions so unexpected that a sense of utter unreality came over me, a feeling which gripped me during the rest of the exploration.

I followed the rail line — scarcely did it seem a prosaic, practical pair of iron rails for carrying salt cars! I walked for forty yards or so, until it forked. At this point I stood facing the two even vaster galleries into which it ran, and if I had been startled before, now I was awed. Both galleries were illuminated, but not nearly so brightly as was the first; lights were far between. A gargantuan stage with twin prosceniums!

Ceilings were higher, receding almost entirely into the shadows. From side to side the massive arches measured fifteen paces. Not far along the left tunnel I could make out a full-sized "steam" shovel (to be exact, it was electrically operated, as were all the underground machines here); yet so disproportionate it looked, standing silently there in that cavity all of sixty feet high, that surely it was a child's mechanical toy. The men alongside it were ants.

White; whiter and glistening near a glowing bulb; unreal, uncanny. Silence tangible, oppressive. I groped on and on. Down corridor after corridor. Tunnel upon tunnel appeared to right, to left. Great *rooms* of salt, dim religious chapels, with a pillar thirty feet square supporting the roof. Labyrinths of rooms, vaults, and turnings. At length I was reaching a section where workings had long ago ceased. No lighting here, except that vague auroral twilight which drifted in from faraway thoroughfares. A place of entombment. Dimness magnified every cavernous vista. Silence. Solitude.

Oh Hollywood — I thought — why have you never discovered this? What a setting for a thrilling, exotic film!

Somehow, after a time, I got back to where I had stepped from the elevator, and was wafted up to a region still presided over by the sun. Back to facts and statistics.

Presently I learned some, and something, too, of the human annals pertaining to this place. . . Thus I return, also to motor cars, automatic refrigeration, and the romance of Avery Island's salt business. . . .

About 1780 a young man on a deer hunt threw himself flat down and began to drink from a spring bubbling out of a crack in the stones. At the first taste he recoiled. It was salt water. Chokingly salt. He returned to his pioneer father's cabin across the marshes and announced his find.

For several decades the local market slowly increased for salt made by crudely, laboriously evaporating this spring water in kettles over wood fires. Came a day when some inquiring mind found out that the spring issued from a great salt bed a few feet below the surface. Pure, solid salt could be taken from it by pick and shovel. A bonanza for a short time! Then it became impossible to work the excavation because surface water flooded it.

For years the mine was abandoned. At length, demand started the evaporating practice once more; this time with improved methods. Business was good again. The Civil War cut off all the South's northern salt supply; Confeder-

ate folk and their armies looked to Avery Island. The owners could not keep up with the demand.

By 1880 so many other salt sources in the United States had been developed that Avery Island's plant closed down. It did not pay to evaporate salt by using fuel. Money was not available for large-scale deep mining. In 1895 the large combine, the International Salt Company, took working control. Soon they cut a shaft 550 feet down into the solid white rock, installed modern machinery. And today this is still the level at which operations are carried on.

Avery "Island" is not an island; it is a large, narrow "hog back" of land a few miles long, bulging to about 200 feet at its summit, rising from the alluvial lowlands, the marshes, and the Gulf shores. Under one end is a "bubble" or dome of solid salt. Miraculous in depth: borings down to 2200 feet have not gone through it. Of unknown area, other surveys have proved it to extend beneath for at least 2000 acres. More salt than the world can ever use....

So here is a place where electric band-saws undercut the "room faces," then dynamite blasts out freight-car quantities at a time. Just like mass-production coal mining. For 30 years they have been gouging out these catacombs! How many train-loads, how many million tons have salted the stock farms of the continent; gone into its chemical industries; savored its human food; frozen its ice creams?

The ranches and farms fed salt in increasing quantities. Later they wanted sulfur, from sulfur workings nearby, mixed with it in big licking-blocks. That helped production. But this type of use soon reached a natural limit. When delivery of almost everything by truck established itself, the ice cream and sherbets of the land began to be factory-manufactured, factory distributed; homemade, storemade freezing went out. Moreover, factories froze by the ammonia process. Salt consumption fell off.

Less salt went out from Avery Island. Presently hundreds of thousands of iceboxes gave way to automatic cooling devices. Meats packed in brine largely fell out of fashion. The salt business was losing its savor.

Yet automobiles spawned endlessly. More gasoline and yet more was demanded. Suddenly a new process of cracking crude oil required plenty of brine to cool the distillate and convey away its heat. Hence brine made from cheap rock salt. Avery Island salt is now beginning a new revival.

LET'S GO TO NEW ORLEANS . . .

Arthur Brisbane was right when he said, "If there are two wonderful cities in this country, New Orleans is one of them. The other is your home town."

We are an average American family that has been discussing for weeks where we shall go on our vacation this year. A vote taken last night revealed the whole family for once agreed on where they wanted to go. The result of this agreement surprised Dad, and he said, "Well, this is the first time I have ever seen the entire family agree on where we'll spend the vacation."

Mother said she wanted to visit New Orleans because she wanted to "get away from everyday surroundings" and go to a place where she has heard that you can do things and see people that are different. She also wanted to visit the famous "garden district" with its tropical foliage and its beautiful homes, which she had heard so much about.

Sister said she was interested in the "French Quarter" (Vieux Carre) where, she has been told, the romance of two hundred colorful years has been preserved. She was also eager to see those cultural displays, and the historic exhibits in the Louisiana State Museum, which her friends, now living in New Orleans, had written so much about.

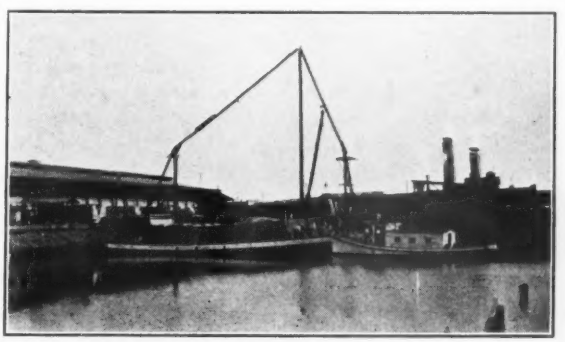
My brother is an engineer, and he is anxious to see the modern engineering constructions in New Orleans that he has been reading about in engineering journals. The most important of these are the Shushan Airport, which has taken its place among the great air transportation centers of the world, and the 13 million dollar, toll-free bridge across the Mississippi River, which is an extraordinary example of America's engineering genius. It is said to be by far the finest of the fifteen major bridges which span the Mississippi River.

My younger brother says that he wants to see the port, where all the products of the Mississippi Valley must pass to get to the sea. Incidentally, a conservative estimate of the river and port improvements are said to be valued at more than $200,000,000.

Dad wants to visit New Orleans because of the ideal climate and the French cooking. Dad says that the Creole chefs of the famous New Orleans restaurants prepare seafoods unlike any other city in America.

Everybody in the family gave a different reason for wanting to visit "America's Most Interesting City." There are many other interesting places to see in New Orleans that we did not mention; for instance, the four million dollar lakefront development where native Orleanians and tourists may ride for miles, feel the exhilarating breeze of the Lake Pontchartrain, and witness the regattas of the Southern Yacht Club, "America's second oldest yacht club." New Orleans also proudly stands foremost as an educational center in the South, with its completely developed public school system, its private and parochial schools, and with several colleges and universities at the apex of the scholastic pyramid.

You can live ten miles from New Orleans or ten thousand miles from New Orleans. Once you have been there you will always want to go back, and you will always be ready to say "Let's go to New Orleans—romantically old—energetically modern . . . "



Schneider Brick & Tile Company, Slidell, Louisiana

WHO BEGAN VITRIFIED PORCELAIN SANITARY WARE MAKING?*

Thomas Maddock, the first successful manufacturer of sanitary ware in this country, was born in England in April, 1818. He served his apprenticeship as a decorator, in the Davenport potteries at Longport. In 1847, with William Leigh, he left England and came to this country, bringing with him tile for the construction of a kiln for firing decorated ware. Shortly after their arrival, the two, Leigh and Maddock, established themselves in the business of decorating china in Spruce Street, New York City. In 1853, they decorated a dinner service for President Pierce for use in the White House. They also decorated table services for the famous St. Nicholas Hotel, of New York, which was opened in 1853. Mr. Maddock afterward engaged in the retail crockery business in Jersey City, N. J., acting as sales agent for Millington and Astbury, manufacturers of pottery in Trenton.

On April 4, 1873, Mr. Maddock formed a partnership with those gentlemen, under the name of Millington, Astbury, and Maddock in Trenton, for the manufacture of earthenware, in which the firm was very successful, and built up a profitable business. Mr. Maddock, however, had become impressed with the idea that sanitary ware, then imported from England in small quantities, might be made in this country to advantage, and he devoted himself to patient and long-continued experiments in that direction.

One or two attempts at the manufacture of this class of goods had been made previous to this time. Isaac Davis and the American Crockery Company of Trenton, N. J., and James Carr of New York had tried it, but found the difficulties too great to be overcome by their ingenuity or resource, and all had abandoned the attempt in 1873. But Mr. Maddock believed that there was a great future for the industry. He saw no reason why, if sanitary earthenware was successfully made in England, it should not be equally well done in this country. He had not himself learned the method of manufacture in England. But he set out to find for himself the best method, not, perhaps, appreciating the long and laborious road that lay before him. The story of his experiments and his failures, before success rewarded him, is an interesting chapter in the history of Anglo-American industry.

The difficulties with which Thomas Maddock had to deal were inherent in all the material with which his work must be done, whether minerals or men.

It was no easy matter to work out the proper formula for the "body" for heavy sanitary earthenware. Table and toilet ware had hitherto been the principal product of the Trenton potteries, and the body most appropriate for such ware would not serve at all in the sanitary ware. Each constituent material had its own value and carried also its own possibility of damage. Too much flint tends to produce "dunting" or cracking. Too much feldspar gives the body an unduly glassy character and makes it apt to bend and craze. If the kiln is not skilfully regulated, the ware warps out of shape. All these things must be looked out for in advance. But with the lack of knowledge and experience concerning these important details, many lots of ware were ruined in the firing.

The losses occasioned by failures in the proper preparation of the body were very heavy. In some cases when fifty pieces were placed in the kiln, forty-five would come out defective. A loss of 90% was far from being profitable manufacture. So much was suffered that Mr. Maddock's partner, Mr. Astbury, who was quite content with the prosperous manufacture of general ware, became entirely discouraged, and could not see why Mr. Maddock wanted to continue experimenting with a line so unsatisfactory when their other business was so profitable.

Besides the difficulty with the material, they had trouble with the operators. There were, of course, no skilled mechanics in that line, and operators did not care to learn how to deal with the new and difficult work. They could make more money on the general ware to which they were accustomed. When they did undertake the handling of the new pieces, there was great probability of loss in the ware coming imperfect from the biscuit kilns. So great was this probability that the men were paid day wages, since, if they were paid upon the basis of ware good from the kiln, as is the usual custom, there would often have been very little coming to them upon pay day. Kilnmen, also, had no knowledge of the method of placing large pieces in the kiln. When the piece came from the kiln to the glaze dipper, he did not know how to handle it. Moreover, besides the lack of expert knowledge, the operatives usually had their own notions of how the work ought to be done; and when once they had determined how they would do it, the manufacturer's wish was of little weight with them.

Time, toil, patience, and indomitable perseverance finally brought Mr. Maddock to the point where he could say that he could make sanitary ware in his factory in the United States. He was able to produce such articles as round basins, French closets, and Philadelphia hoppers. The ware was not of a high class. Dunting and crazing were common. The Henry C. Meyer Company kept in their basement a vat, or tank, of water which they used for testing closets. When they unpacked a crate, they would put the pieces in the water in the tank and let them remain for some hours. After a test of this kind, it was not unusual that 25% of the ware would be dunted through the seams where the parts were stuck together. But poor as it was, it was practical, usable ware.

The next difficulty before Mr. Maddock, therefore, was that of marketing the product. The first step was to convince the jobbers that this American ware could be used in place of the imported, and this was a more difficult undertaking than producing the goods. At that time there were only a few jobbers in the United States, and they were dealing only in imported goods. Only four English potters were exporting sanitary ware to the United States, namely (1) Brown, Westhead, and Moore, (2) Twyfords, (3) Brown of Paisley, and (4) Dimock. Mr. Maddock was obliged to display his American ware before the eyes of the jobbers before they would give it the slightest consideration, and when it was shown to them they would have none of it. It was only after long and laborious urging of his

* From Pottery, pp. 19–30, incl. Published by Thomas Maddock Sons Co., Trenton, N. J. Designed and arranged by Frank Spencer; printed by Dando, Philadelphia, Pa. See also *Ceramic Industry*, pp. 137–46 (August, 1925); *The Ceramist*, pp. 565–600 (July, 1935); *The Ceramist* is now called *Ceramic Age*.

ware that the persistent manufacturer was able to persuade one firm to give a small order.

Mr. Maddock's method of presenting his goods was unique and characteristic. As might be supposed from his struggle with the process of manufacture, he was accustomed to depend upon himself. He would not ride in a car if it were possible to walk. He never wore an overcoat or carried an umbrella. And he would himself show the goods he had succeeded in making and was determined to sell.

Accordingly, he would get a piece of slate-colored muslin, about the size of a table cloth, spread it upon the floor, and place in the center, one above another, a 14-inch P.O. basin, a 14-inch C.O. basin, a 14-inch R.P. basin, and a French closet, the whole weighing from 45 to 50 pounds. Tying the corners of the cloth together to serve as a handle, Mr. Maddock would swing his burden up in his hands and start off on his wearisome journey to the dealers. He carried these samples around the lower part of New York City, there being no jobbers above Canal Street at that time, and to the dealers in Brooklyn, day after day, with little or no encouragement for the first six months.

After returning to the factory from a hard day's work in soliciting orders without success, Mr. Maddock's partners would urge him to relinquish the bootless endeavor, pointing out the folly of worrying with this class of goods, with which they had so much trouble and loss, while they could make general ware with no trouble and the trade would readily take all they could make at a good profit. But Mr. Maddock believed in his ware. After many disappointments he succeeded in interesting Miller and Coates of New York, who gave a small order for the Maddock goods, and the prosperous development of the American sanitary pottery industry was begun. This was the last part of 1873.

But even then the ware could not be sold as genuinely an American product. The only condition under which the trade could be induced to place orders was that each piece of ware should be branded with a large stamp, with the familiar imprint of the lion and unicorn fighting for the crown, and the words, "Best Staffordshire Earthenware Made for the American Market."

After Miller and Coates began buying the goods, Waeffelaer and Duysters placed some orders with Mr. Maddock. As soon as it became evident that he could make the ware and that it could and would be used where the imported goods had hitherto occupied the field, the same Waeffelaer and Duysters offered to make an agreement with him to take the entire output of his factory. This offer he declined, on the ground that a number of jobbers were already handling the ware, and that if he should give one firm the monopoly of the product he would be required to refuse other customers, and would be at the mercy of Waeffelaer and Duysters. He continued, therefore, to furnish his goods to all who would buy, so far as the capacity of his factory would permit.

John Maddock*
Cabinet Maker in
Burslem, Staffordshire, England

John	Thomas
Decorator at Davenport Porcelain	Decorator at Davenport
John, Jr. Established in Burslem the John Maddock & Sons Porcelain	Widow and eight children came to America
	Second son, Thomas, born in Burslem, England, April 1, 1818. Moved to New York in 1847. Engaged in pottery decorating.

In 1872 Thomas Maddock bought interest in Carrol Street Pottery of Millington and Astbury and began producing sanitary earthenware. Thomas Maddock became sole owner in 1878. In 1882, he and his four sons organized the Thomas Maddock & Sons. In 1892, they bought the Trenton China Co. and formed a separate corporation, "Maddock Pottery Co., Lamberton Works." City Pottery was purchased in 1886 and Glasgow Pottery in 1906.

John, born 1848	Charles S., born 1852, died in 1933	Archibald, born 1856, died in 1910	Harry S., born 1865, died in 1914
Thomas Alexander H. William B. Harry E.	Archibald M., and Charles S., Jr., became active in 1898 and 1899, respectively.		Harold S., became active in 1910.

In 1895 John withdrew from Thomas Maddock and Sons and with his four sons organized John Maddock and Sons, Coalport Works.

Thomas, Sr., retired in 1883 and died in 1899. Age 82. In 1902 the firm was reincorporated as the Thomas Maddock's Sons Co. They built a modern plant at Hutchinson's Mills, N. J., Hamilton Township in 1924, and began operations in 1925, with Charles S., Sr., Archibald M., Charles S., Jr., Harold S., and E. D. Anderson, Directors.

An incidental item of Mr. Maddock's ingenious labors with sanitary pottery was his invention of the method of fastening a brass coupling to earthenware. Prior to his patent of June 29, 1880, all closets were connected with the lead pipe of the plumbing by means of a porcelain horn, extending from the flushing rim of the earthenware. The lead pipe was thrust inside the horn, the crevice filled with putty, and the whole held firmly together by binding with strips of muslin. Mr. Maddock's invention made it possible to couple the plumbing directly to the earthenware by means of a brass coupling, and that method is now almost universally followed.

Mr. Maddock lived long enough to see the great and abundant success of his laborious and patient experiment. Not unlike the famous potter, Palissy, he was aided in all his labors by the sympathy and encouragement of his wife, Isabella Smith (nee Middleton) Maddock. As it became evident that there was practically an illimitable field for American sanitary ware, other potters entered upon the manufacture, in some instances abandoning the manufacture of general ware and transforming their factories for the making of sanitary ware alone.

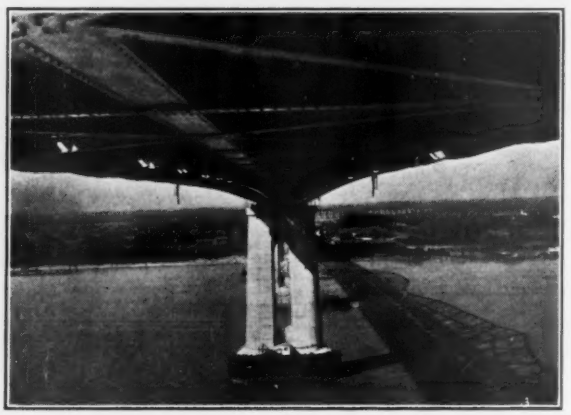
Millington, Astbury, and Young operated the city pottery 1853–1859, at which time Millington and Astbury established the Carrol Street Pottery, now Thomas Maddock's Sons Company (1928).

A POST-MEETING MOTOR TOUR TO MEXICO

The Sinclair-Pierce Oil Company, S. A., Offers Its Services*

During the past month we have received several inquiries from members of your Society, requesting information on motoring in Mexico. They state that if they do attend the meeting in New Orleans next March, they wish to make a post-Meeting trip to Mexico City and want full information covering such a trip.

Believing that others will be interested in motoring through Mexico and a post-Meeting trip to Mexico City might be made an additional attraction, I take the liberty of offering our coöperation in supplying information and placing at your command our staff in Mexico, so that those of your members who visit us will feel that they are receiving special attention and consideration due to the arrangements that you are making for their comfort and safety.



Pilot's-Eye View of the Huey P. Long Bridge

A pilot's-eye view as his ship passes under the new $13,000,000 Mississippi River bridge at New Orleans. It was opened with a pageant depicting 218 years of the evolution of transportation at the nation's second most important port.

The pier in the foreground rests on firm sand 170 feet below the level of the water, 90 feet below the bottom of the river, which is 80 feet deep at this point. A vertical clearance of 135 feet at high water is provided.

The bridge is used by Southern Pacific trains. The vehicular section is toll-free. This bridge is the river's only crossing south of Vicksburg. It is 112 miles from the river's mouth. It is a new link in U. S. Route 90—the Old Spanish Trail.

I do not suggest a motorcade or any special efforts to organize groups or parties. It is my recommendation that you give publicity to the suggestion that those who wish can motor on to Mexico City after the Meeting. I believe such a suggestion will appeal to many of your members.

The Sinclair Refining Company organization, through its Mexican affiliate, the Sinclair-Pierce Oil Company, is in an especially favorable position to give a constant and intelligent supervision over a post-Meeting trip to Mexico City. Our Laredo Tourist Office (same as Sinclair Station) will attend to the Mexican Government requirements as to passport and car permit, as well as arranging hotel reservations so as to avoid unnecessary delays and annoyances. There are twelve stations located at convenient points on the highway between Laredo and Mexico City. The "Red Rooster" emblem is seen throughout Mexico off the highway, but in the cities and towns through which it passes are other "Red Rooster" stations. The Tourist Department has a sub-office at Valles, the midway point between Monterey and Mexico City. One can keep in continuous contact with the Sinclair organization throughout his stay in Mexico.

The Tourist Department is non-profit making. It makes no charges for its services.

New Orleans is 735 miles from Laredo, Texas, which is 762 miles from Mexico City—1497 miles of paved highway. For the members living east of the Mississippi, the Mexico City trip can be made as an extension of the journey to New Orleans via Houston and Laredo, Texas, and will take about four days of motoring. The members west of the Mississippi can run down to Mexico City as part of their return trip home. Mexico City is 1108 miles from Houston—3 days from Houston. The post-Meeting trip to Mexico City will add 10 days or two weeks to the time normally taken up in attending the Meeting.

For information as to the cost of this post-Meeting trip, maps, and folders, write to A. R. Coleman, *Manager*, Tourist Dept., Sinclair-Pierce Oil Company, S. A., 55 Balderas, Mexico, D. F., or to the nearest Sinclair dealer.

* This letter was received from A. R. Coleman, Manager of the Tourist Department of the Sinclair-Pierce Oil Co.

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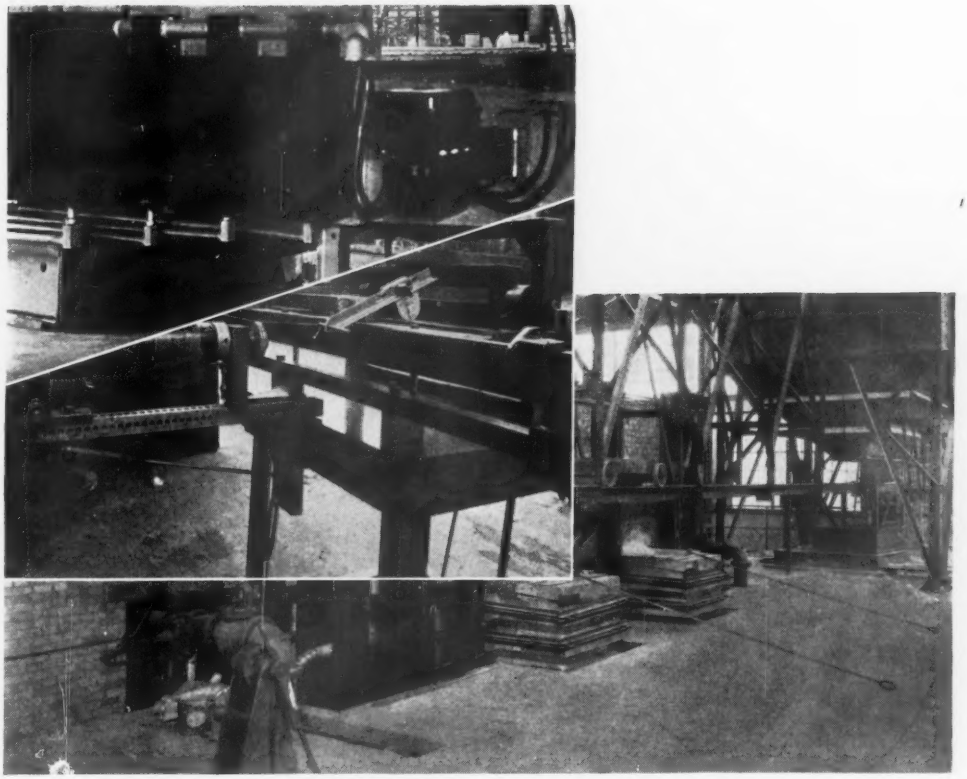

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TALC WHITING

Beautiful

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This is the headline of the ARMCO advertisement featuring porcelain enameled products, soon to appear in "Good Housekeeping," "Time," and "American Home."

Over four million readers of these magazines will see this message. Once again we are reminding them to look for the familiar ARMCO label—their surest guide to finest quality and enduring beauty when purchasing anything made of porcelain enamel.

For many years ARMCO advertising has been a powerful influence in stimulating the increased sale of better porcelain enameled products. Manufacturers who standardize on ARMCO Enameling Iron—and label their wares with the well-known ARMCO triangle—have profited generously. Write us for full information. The American Rolling Mill Company, Executive Offices, 703 Curtis St., Middletown, Ohio.

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Only five cities in the United States have populations exceeding the number of security holders and employees of the Bell System. There is one security holder for every 165 people in this country.

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NEWPORT, KY.

Puryear, Tennessee
August 8, 1937

Mr. Pete Potter
Comfortable Sanitary Pottery Mfg. Co.,
Pottsville, Ohio

Dear Pete:

Well, Old Timer, as far as I can see there is just no use taking the thing so seriously. You can't control everything. Now yesterday we thought we were really rolling with full steam ahead, and then—no sit down strike—but all the white men quit to go to town to vote, and the niggers all began celebrating Emancipation Day. Our man lost the election and one of the niggers says, "Mr. Lincoln didn't free 'um on August 8th, it was on January 8th." I suggested we just go on working and celebrate next January, but he said, "No. A nigger just can't celebrate in cold weather and without watermelon," so they started "Raising a Ruckus" yesterday. Tomorrow will be "Blue Monday" sure enough. But we'll make it! The job must go on!

Say! The New Dealers are going Russian on us, aren't they? Old Man Garner went to Texas and came back acting like he had some sense, and then yesterday he changes our Federal Courts without even letting the boys vote. Just any day now they will set up a Board of five men in Washington to run everything. They come here "buck jumping" but they won't last long. Surely there will be another Lincoln to emancipate the people that are willing to work and want to run their own affairs in the Good Old American Way.

Well, whatever happens, Pete, you can always get Good Old Dependable SPINKS' CLAYS. We can and will control their uniformity and keep plenty on hand in the sheds.

Sincerely,

Dick Carothers

General Manager
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